S
181
.E7

B 395744

THE UNIVERSITY OF MICHIGAN · LIBRARIES ·

Issued July 10, 1915.

PORTO RICO AGRICULTURAL EXPERIMENT STATION, Mayaguez
D. W. MAY, Special Agent in Charge.

GENERAL LIBRARY
AUG 25 19[illegible]

REPORT OF
THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1914.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915.

Issued July 10, 1915.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge.

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1914.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

D. W. MAY, *Special Agent in Charge.*
P. L. GILE, *Chemist.*
C. F. KINMAN, *Horticulturist.*
G. L. FAWCETT, *Plant Pathologist.*
R. H. VAN ZWALUWENBURG, *Entomologist.*
T. B. MCCLELLAND, *Assistant Horticulturist.*
J. O. CARRERO, *Assistant Chemist.*
C. ALEMAR, Jr., *Clerk.*

LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., February 15, 1915.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1914.

Respectfully,

D. W. MAY,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

	Page.
Summary of investigations	7
Introduction	7
Natural resources and conditions	7
Reforesting	9
Guano deposits	9
Live stock	10
Forage and cover crops	11
Fiber crops	11
Rural credits	11
Cooperation and marketing	12
Improvements and extension	12
Report of the chemist and assistant chemist	13
Introduction	13
Analytical work	14
Fertilizer experiments on the red clay soil	14
Chlorosis of sugar cane	14
Lime-induced chlorosis	15
Bat guanos	16
Report of the horticulturist	17
Introduction	17
Results with miscellaneous crops	17
Mango	17
Root crops	17
Citrus fruits	18
Citrus fertilization experiments	18
Coconuts	19
Leguminous cover crops	20
Report of the assistant horticulturist	23
Coffee	23
Cacao	25
Vanilla	25
Miscellaneous	25
Report of the plant pathologist	27
Introduction	27
Coffee diseases	28
Cacao diseases	29
Diseases of citrus trees	30
Report of the entomologist	31
Introduction	31
The changa	31
Coffee leaf miner	32
Coffee shade pests	33
May beetle	34
Miscellaneous pests	34
Honeybees	35

ILLUSTRATIONS.

Page.

PLATE I. Fig. 1.—Exterior view of new plant house. Fig. 2.—Interior view of new plant house — 12

II. Fig. 1.—Coconut plantation, Boquillas. Fig. 2.—Coconut fertilizer plats, Boquillas — 20

III. Fig. 1.—Vanilla in flower. Fig. 2.—Mahogany tree 2 years old — 24

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1914.

SUMMARY OF INVESTIGATIONS.

By D. W. MAY, *Special Agent in Charge.*

INTRODUCTION.

Porto Rico, with an area of 3,600 square miles, has a population of over 1,000,000. The population is increasing, as is likewise the agricultural production. There is but little increase in manufactures and it is not probable that the island is destined to become a manufacturing country, as there is no coal and but little water power. The population is largely rural, and with present desires and training will remain so.

During the year 1914 the agricultural interests have faced several crises. The reduction of the duty on sugar has seriously affected the leading industry and has been greatly felt in all lines of business. Again, the European war has hit hard the coffee growers, as the crop is largely sold abroad. Fruit shipped to the United States has sold lower than at any time since the establishment of the industry in Porto Rico. As a result of present conditions, both exports and imports have decreased.

In order to somewhat relieve the situation a more thorough study of the soils should be made, with a view to increasing their productiveness, and there should be more diversification of crops. There should be more and better live stock on the farms to improve the living condition of the planters, as well as to yield an additional income.

NATURAL RESOURCES AND CONDITIONS.

Porto Rico is an old-settled country. Permanent settlements were made here before they were in the mainland of North America. Moreover, the island is and has been for many years thickly populated. It is not strange, therefore, that the natural resources of the country have been thoroughly exploited. The forests have been consumed, and, with charcoal as the fuel used for cooking, reforestation has made no headway. The fertility of the soil, the greatest natural resource of a country, has been very largely depleted by an unscientific agriculture. The agriculture needed, therefore, is necessarily a constructive one.

As the products come primarily from the soil, it is to the soil that the highest skill should be applied. Contrary to general belief, tropical soils are not naturally fertile. It is true that in virgin forests, where humus deposits have accumulated for many years, they are quite productive, but that fertility must be very carefully conserved or it will be lost, and that, too, not by cropping. Denuded of trees, tropical upland soils soon lose their fertility by the washing and leaching of rains and the action of the burning sun. Where covered with forests, especially of leguminous trees, they are productive for coffee, cacao, etc., but when bare they become hard and compact, not holding moisture and producing only scant, unprofitable grasses. It is a slow and tedious process to bring these lands back to the production of profitable crops or trees.

It is true that the growing season in the Tropics is 12 months of the year, yet the quick growth of vegetables known in the north in the spring is not obtained in the Tropics. Persons from the temperate zones, seeing the misery among many of the rural population, ascribe the condition to shiftlessness, while in the main it is due to ignorance. The natural conditions are such that the small planter can not get the immediate results with salable crops that are obtained in the spring season in the north.

What is the cause of this? In northern climates the freezing of winter puts the soil in a favorable condition or releases plant food therein, producing conditions for rapid spring growth. In the Tropics these favorable conditions do not exist, and plants which require a long period of growth are the most successful. The use of fertilizers becomes more necessary.

In Porto Rico the level lowlands are by far the most productive. The great problem in connection with these soils is one of rotation. At present they are largely devoted to sugar cane, but natural conditions have already compelled the adoption of rotations, and this will be accelerated by reason of change in economic conditions and the consequent lowering in the price of sugar. Doubtless many of the cane lands will go into grass, with a resulting increased production of live stock.

The hill lands offer a more serious problem. Those that have not been stripped of their forests have been largely planted to coffee and fruit trees, which, growing beneath certain leguminous trees, are protected from the fierce rays of the sun and the force of the wind, and aid in conserving the moisture. Moreover, the leguminous nurse trees store nitrogen in the soil, which serves to nourish the economic trees of lesser height growing under them. Hill lands that have been denuded of their forests produce only sparse grasses, affording but little sustenance to horses and cattle. To bring them back to profitable production requires time, skill, and capital. When the timber is cut from such lands they are robbed of almost their entire value. They soon lose their humus, and fertilizers applied give but meager results. Leguminous plants are needed to improve such lands, and, fortunately, there are a number available. These range from the native beggar weed, sensitive plant, and the wild peanut, trailing along the ground, to the cowpea and velvet bean of larger growth and high feeding value. Of leguminous trees the guamá (*Inga laurina*) and guava (*Inga vera*) have long been used, while some other lesser known and introduced kinds have a high value in reclaiming barren hills and bringing them again into cultivation. In the Tropics, where there is no frost, the soil should be covered with vegetation at all times. In this way the fertility is best conserved. When a direct money crop is not growing there should be legumes.

REFORESTING.

Porto Rico is situated in the Tropics and at the door of the eastern seaboard of the United States—the best market in the world. Intensive farming therefore should be practiced. Tree products will prove the most prolific per area and orchard products will doubtless prove to be the leading ones. In order to get the lands planted to fruits, coffee, and nuts, leguminous trees are generally considered the best nurse crops.

The station has 200 acres of hill land on a mountain above Mayaguez. This has been cut over for a number of years and the soil is badly gullied. An experiment in reforesting this area is under way, and about 120 acres have been planted to leguminous and hardwood trees. Among the legumes, the guamá (*Inga laurina*) and the cojoba (*Copaifera hymenæifolia*) are the more promising at this time. The indications are that mahogany will do well, and as a fruit tree the mango is proving valuable for planting in such situations.

In reforesting the island, leguminous trees should have first consideration, as they improve the soil and serve as nurse trees for all others. As trees that will do best without nurse trees, from trials of a great many, the eucalyptus, mahogany, and mango are the most promising. The swamp mahogany (*Eucalyptus robusta*) is the best of that genus. Only the improved varieties of mangoes should be planted, as the common sorts are of little economic value.

GUANO DEPOSITS.

One natural resource of Porto Rico that has been utilized to but a small extent is the bat guano deposited in the caves of the island. The station has begun a survey of these deposits and is estimating their extent and value. Some samples run quite high in phosphoric acid and have a measurable percentage of nitrogen. The more accessible caves, no doubt, will yield a more economical fertilizer than that now imported, and reduce somewhat the amount of money sent abroad for this product.

LIVE STOCK.

The horse stock on the island has been much improved in the last eight years, mainly by the use of purebred sires. The station has imported 8—5 saddle bred, 2 thoroughbred, and 1 Morgan. Several additional ones have been imported by planters. The types best suited to crossing with native stock are the lighter breeds, thoroughbred, trotting, and saddle horses.

The most successful sections for horse breeding are the limestone regions of the south side of the island, where Guinea grass flourishes at its best.

Cattle raising is again becoming important, especially as the sugar situation is compelling many of our planters to consider rotations in the use of cane lands.

There have been many importations of cattle, with varying success. The great drawback is the cattle tick, which not only causes losses from tick fever but increases the cost of production. No animal can thrive on a minimum amount of feed when it acts as host to a large number of voracious blood-sucking insects. Before cattle growing can reach the highest success the tick must be eradicated. As cattle are used largely for draft purposes a campaign for tick eradication must have not only the cooperation of the planters but of those engaged in transportation as well. Considerable time and expense will be required in exterminating the tick from the island, and it will be necessary to have an aroused public sentiment back of the work to insure its success. No expenditure of a like sum promises such large results to the people of Porto Rico as the eradication of the cattle tick.

Two years ago an epidemic disease among swine swept over the island and caused large losses. The station herd was entirely wiped out. The disease seems to have ceased and hog raising is again increasing. Such animals are easily grown here, and there are a variety of plants and waste products that furnish food for them.

There is a marked improvement in poultry everywhere, and the heavier breeds are becoming quite common where a few years ago only the small game chicken was found. The production of poultry on a large scale has proven profitable in several instances and poultry raising among the small farmers and agricultural laborers is becoming more general. Poultry products are relatively high in price and are in constant demand. They afford the first incentive to the peon classes to improve their condition by producing and offering for sale something besides unskilled labor, which is nearly always in excess of the demand in Porto Rico.

FORAGE AND COVER CROPS.

Among recent introductions two crops rank high in value to the island: Velvet beans (*Stizolobium* spp.), rank-growing legumes, are of value as green manure and also stand high as feed for stock. The sword bean (*Canavalia* sp.) has been widely distributed by the station, and is now quite generally grown in the citrus orchards as a cover crop. The velvet bean is supplanting the sword bean, as it gives a larger growth and also affords good feed for horses, cattle, and pigs.

Sudan grass won instant popularity, especially in the dry sections of the island. It makes a wonderful growth with a minimum rainfall and is well relished by live stock. It is easily grown from seed and, as it is a bunch grass, it is not likely to prove a pest. In regions of abundant rainfall it makes a rank growth, but it is difficult to obtain seed, due to a fungus attack of the head.

FIBER CROPS.

The station, in cooperation with the insular government, planted 75 acres of dry land on the south coast to sisal and henequen. The growth has been slow and the results have not been such as to induce private capital to take over the enterprise and extend it. As the machinery necessary for the successful extraction of this fiber costs several thousand dollars, it would require a large and successful planting to justify the expenditure. As the lands in Porto Rico are mainly in small holdings and the value much above that of lands in other countries where this fiber is produced, it does not seem promising unless efficient and less expensive machinery can be devised that will justify its exploitation on a smaller scale.

Carludovica palmata, used in making the Panama hat, was introduced by the station several years ago, and it has been widely distributed and seems destined to supplant the native palm (palma de cogollo) now used for this purpose in Porto Rico. It not only makes a better and more valuable hat but is easier to weave. As the exports of hats during the year amounted to $262,364, the importance of the improved strain to our weaving industry can be readily seen.

RURAL CREDITS.

In the matter of the planter securing money for either long or short loans there are two serious drawbacks in Porto Rico. One is the high cost, 12 per cent per annum being the usual rate, and the other is the cumbersome and expensive title and recording regulations. The notary and stamp fees in the ordinary transactions in land are so excessive as to almost prohibit the small landholder from securing money on his property. Some simpler method, as the Torrens system, would reduce the cost of making out the necessary papers, and also, by simplifying such transactions and quieting titles, reduce the rates of interest.

COOPERATION AND MARKETING.

Cooperation continues among the cane growers, especially in looking after legal matters affecting the industry. The fruit growers maintain an efficient organization, with an office in New York for marketing their products. They also cooperate in the buying of supplies, such as crates, fertilizers, etc. This organization is growing and doing much good. The tobacco growers have an organization. The coffee growers have an organization, but it has not made much progress. Their efforts have been directed toward marketing their product in the States instead of in Europe. The association lacks cohesion and the backing of the coffee growers.

IMPROVEMENTS AND EXTENSION.

The station during the year has erected, under an appropriation of the insular government of $6,000, a plant house, and has remodeled the old sugar-mill building that in the beginning housed the office and laboratories. The plant house is 88 by 124 feet, partly covered with glass and partly with wire netting. An additional weighing room, 30 by 15 feet, made of cement and covered by tile, was constructed. This house is equipped with cars and tracks, on which pots are mounted for soil and plant studies. (See Pl. I, figs. 1 and 2.)

The old sugar-mill building, 29 by 196 feet, had the south wall torn out and rebuilt and was covered with a tile roof. It is used for the storage of heavy chemicals, apparatus, and hand machinery.

The improvement of the station grounds was continued, wooden culverts, fence posts, etc., being replaced with cement structures.

The distribution of seeds, plants, and cuttings has been larger than in any previous year. This includes valuable importations which have been tested at the station and others of local origin and improvement.

The correspondence and field work of the station staff continues to expand. This work is of such amount as to hamper the research work of the station, yet its importance calls for more effort along these lines. Provision for extension work in Porto Rico would, it is believed, be of material assistance to the planters and serve the important purpose of bringing the results of research directly to their attention—a matter very much to be desired.

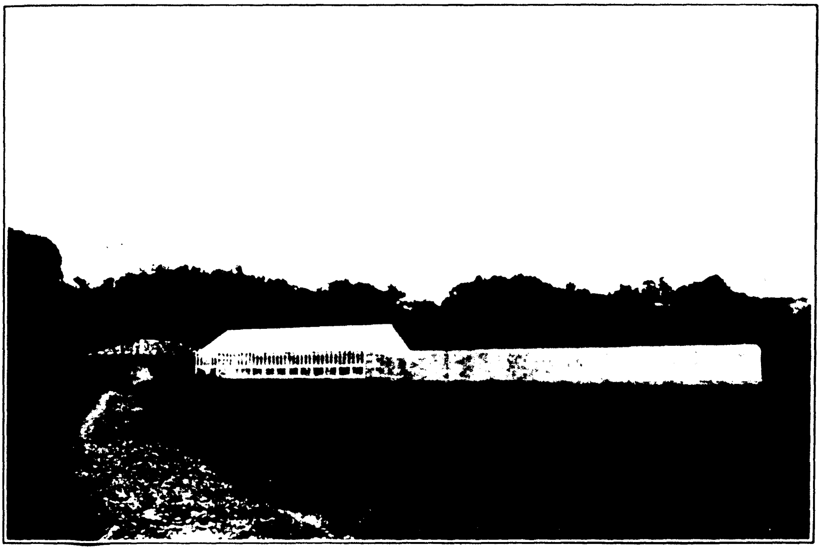

FIG. 1.—EXTERIOR VIEW OF NEW PLANT HOUSE.

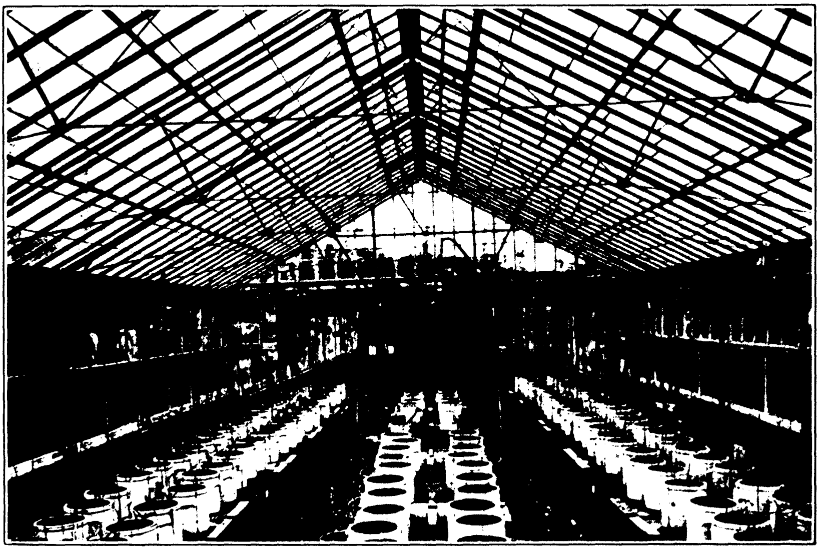

FIG. 2.—INTERIOR VIEW OF NEW PLANT HOUSE.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and J. O. Carrero.

INTRODUCTION.

The work the past year was continued along the lines noted in the previous report. Progress in several investigations requiring quantitative vegetative experiments was considerably furthered by use of the new plant house. The equipment for carrying on vegetative experiments in pots, which was completed in August, comprises a small house for mixing soil, preparing pots, and drying samples; a glass house, with a weighing device, for protection of the plants during heavy rains; and a wire rat-proof inclosure, where the pots are kept during favorable weather. The houses and inclosure carry tracks and trucks sufficient for about 200 large pots. (Pl. I, figs. 1 and 2.)

ANALYTICAL WORK.

The analysis of some 50 plant ashes, in connection with the investigations detailed below, formed the chief part of the analytical work for 1914. Various samples of lime, fertilizers, guanos, molasses, water, and miscellaneous materials were also analyzed.

In the course of the work with plant ashes the permanganate method for determining iron was compared with the potassium sulphocyanate colorimetric method. The colorimetric method was found preferable for the determination of the small amounts of iron contained in most plant substances. Duplicate results obtained by this method checked very closely, while duplicate samples, run by the permanganate method at different times, occasionally varied considerably. The colorimetric method gave lower results than the permanganate method, particularly when the quantity of iron determined was very small, viz, only a few milligrams or tenths of a milligram. With fairly large quantities of iron the two methods agreed, as was expected.

In determining a milligram of iron with a fortieth-normal solution of permanganate, the quantity of permanganate required for oxidation is so small that a slight difference in reading the burette makes a large percentage difference in the result. The colorimetric method is also more rapid, in that repeated evaporations with sulphuric acid to expel chlorids and subsequent reduction with zinc are unnecessary.

FERTILIZER EXPERIMENTS ON THE RED CLAY SOIL.

The fertilizer plats with sugar cane which were laid out in the Anasco Valley in 1913 were cut in April, 1914. The soil was slightly different from the ordinary red clay soil, but was more nearly related to this type than any other. The detailed results of this experiment, which comprised 73 plats of half an acre each, will be published with those of other tests at a later date. The results showed, however, that lime, nitrate of soda, sulphate of ammonia, dried blood, a nitrogenous and phosphatic fertilizer, and a complete fertilizer all failed to increase appreciably the yield of cane on this soil.

It had been previously observed that liming and nitrogenous fertilizers increased considerably the productivity of some of the red clay soil for sugar cane. This experiment, which was designed to measure on a larger scale the increases produced by those materials, merely emphasizes the fact, already pointed out, that all the red clay soil does not respond to fertilizer.

Three more series of tenth-acre plats, embracing some 225 plats in all, were laid off on different fields of red clay soil in the Anasco Valley last year. On two fields the plats were planned to show the response of this soil to nitrogen, phosphoric acid, and potash, used singly and in combinations furnishing two elements and all three elements. All the fertilizers were applied on the basis of 50 pounds of each element per acre—i. e., sufficient fertilizer to furnish 50 pounds of nitrogen, 50 pounds of potash, etc. Sulphate of ammonia, double superphosphate, and high-grade muriate of potash were used.

The third series of plats was devoted to a comparison of the effectiveness of four different nitrogenous fertilizers on this soil. Nitrate of soda, cyanamid, and tankage were compared with sulphate of ammonia. All plats in this series received a heavy application of potash and phosphoric acid. In addition, sulphate of ammonia was applied at the rate of 20, 35, and 60 pounds of nitrogen per acre, while the nitrate of soda, cyanamid, and tankage were all applied at the rate of 35 pounds of nitrogen per acre. The cane on these plats will be cut in the early part of 1915.

The experimental plats are all located on the property of Guanica Central and the fertilizers employed were furnished by the company.

CHLOROSIS OF SUGAR CANE.

The second series of plats at Central Cortado, which were designed to measure the effect of ferrous sulphate and stable manure on the development of chlorotic cane, were cut in January, 1914. The ferrous sulphate and stable manure were applied in smaller amounts on these plats than on the former series, to see whether a moderate money value of these materials would produce a profitable increase in the tonnage of cane. There were 20 plats, of one-fourth acre each, with four different treatments, so that each plat was replicated five times. The results seem to show that small applications of these materials have but little effect on the cane. The heavier applications in the former series of plats seemed to produce quite notable increases in tonnage but at a prohibitive cost.

The American Steel & Wire Co. kindly furnished the sulphate of iron for these experiments and the Santa Isabel Sugar Co. the facilities for carrying on the work.

Analyses have been made of several samples of chlorotic and green cane leaves. This work will be continued the coming year, as a considerable number of samples must be examined before any conclusions can be drawn.

It is rather difficult to study the chlorosis of sugar cane by direct experiments, as experiments in pots can not very well be carried on with this crop.

LIME-INDUCED CHLOROSIS.

The work on this subject has been confined to experiments with rice, since this plant is practically as sensitive as the pineapple to carbonate of lime, and is well adapted for growth in pot cultures and nutrient solutions.

From work already reported[1] it appears that at least one action of the carbonate of lime in inducing the chlorosis lies in depressing the assimilation of iron. An attempt is being made to determine whether this is the sole action of the lime or whether it is more complex. A number of experiments have been conducted for this purpose. For the proper interpretation of some of the results obtained, further experiments on related or general subjects were necessary. For instance, when studying the ash composition of green and chlorotic rice plants it was necessary to know how the ash composition of normal rice plants varied at different periods of growth. Accordingly, complete ash analyses were made of the plant at six stages of growth. The results of this particular work are being prepared for publication.

While considerable data has been obtained on the action of carbonate of lime in inducing chlorosis, much work is yet to be done. An experiment was conducted applying ferrous sulphate to the soil and leaves of chlorotic rice grown in calcareous soils. The results were similar to those obtained in previous work with pineapples.[2] Ferrous sulphate applied to the leaves as a spray restored the green color and induced a normal growth, but applied to the soil was without effect.

Since chlorotic plants contain more lime as well as less iron than normal plants, two experiments have been conducted on the effect of gypsum on the growth and appearance of the plants. An attempt was also made to see whether chlorosis could be induced by increasing the lime and diminishing the iron content of the plant without the action of carbonate of lime.

---

[1] Porto Rico Sta. Bul. 16.

[2] Porto Rico Sta. Bul. 11, p. 32.

Some work has been done on the effect of the reaction of the soil or nutrient medium in bringing about chlorosis and influencing the assimilation of iron. For this purpose one experiment with soil cultures and two tests in nutrient solutions have been carried out.

With the idea of determining the forms of iron that are available to rice, a number of different organic compounds of iron have been tried in a pot experiment with a normal and calcareous soil. A test with colloidal iron was also conducted in water cultures. The results of this latter test were recently published.[1]

One experiment was tried which promised to give rather direct evidence on the whole subject. The results, however, which were not as conclusive as had been anticipated, brought into question the extent to which plants are able to exercise the power of selective absorption. This is being investigated in nutrient solutions.

BAT GUANOS.

Since the completion of the new plant house considerable progress has been made in determining the fertilizing value of the bat guanos already collected. Now that adequate facilities are available, the work will be prosecuted more rapidly and on a more comprehensive scale.

A survey of the caves has been commenced to determine the location of the principal caves, the approximate quantity of material they contain, and the accessibility of the deposits. Samples of the different classes of material present in each cave are being collected for analysis. The chief types of guanos, as ascertained by chemical analysis, are being tested by vegetation experiments in pots to determine the availability of the nitrogen and phosphoric acid. In connection with the vegetation tests it has been necessary to do some work on the methods of conducting such experiments.

The work accomplished so far shows that these deposits vary greatly in chemical composition, but that there are several more or less well-defined types. The vegetation tests show that the availability of the phosphoric acid also varies greatly.

These deposits appear quite numerous and well distributed over the island. There is probably no doubt but that the deposits can furnish valuable fertilizing material for certain districts of the island. The individual deposits, however, are probably too small and transportation on the island too costly for the guanos to be exploited on any scale commercially.

---

[1] U. S. Dept. Agr., Jour. Agr. Research, 3 (1914), No. 3, p. 205.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

INTRODUCTION.

The principal lines of work conducted during the past year include experiments with the following: Mangoes, coconuts, bananas, pineapples, leguminous cover crops, root crops, citrus fruits, eucalyptus trees, and a number of plant introductions. The work has not been confined to the experiment station, but many experiments have been carried on in cooperation with plantation owners. In response to requests from planters and for the purpose of studying various crops and conditions numerous trips have been made to various parts of the island. The demand for cooperative experiments and inspection trips increases from year to year on account of the rapidly growing horticultural interests.

RESULTS WITH MISCELLANEOUS CROPS.

MANGO.

Among the East Indian varieties of fruit, Amini and Cambodiana have been the most promising this year. The fruit of both of these varieties is medium in size, but of excellent texture and flavor. The Amini is handsome and tough skinned and should stand shipping well. The Cambodiana, having a thin, tender, easily broken skin, is suited to home use and should be grown in every Porto Rican fruit garden. Work in propagation and nursery practice has been continued and many nursery trees set in the testing orchard. Over 400 trees, including over 60 imported varieties, are now under cultivation.

ROOT CROPS.

Work with yautias, dasheens, yams, sweet potatoes, etc., is being continued. The experiments include ridge versus level planting, large versus small tubers for planting, distance plantings, fertilizers, and variety tests. In cooperation with planters variety tests of dasheens, yautias, and sweet potatoes have been conducted near San Juan, P. R., on the sandy coastal plains. While all the root crops produce well in the heavy soils at Mayaguez, the first crop of yautias grown on the sandy soils has been unsatisfactory. But few of the varieties proved sufficiently prolific to warrant commercial cultivation. The dasheens were more promising, though not heavy producers. Some varieties of sweet potatoes have given good returns, while many are not profitable under these conditions. Further experiments will be conducted on this type of soil.

CITRUS FRUITS.

Work with citrus fruits has been along lines of fertilization, testing of various stocks, the introduction of promising varieties, and the planting of an experimental grove. This grove set to grapefruit is situated on rolling upland, such as is usually set in coffee. The work was undertaken to test the effect on grapefuit trees of different degrees of shade and wind protection provided by the old leguminous trees and to determine whether this type of land is suited to grapefruit culture.

CITRUS FERTILIZATION EXPERIMENTS.

The experiments in citrus fertilization undertaken in 1905 in cooperation with citrus growers and the German Kali Works have been concluded and the results prepared for publication.[1] Valuable data have been obtained from these experiments in determining the necessity for fertilization and the most satisfactory sources for nitrogen and potash. An important conclusion reached in this work, and one which is being demonstrated by many growers, is the unquestionable need of citrus trees for fertilizers. In plats where trees were not fertilized the growth was slow and the crop of fruit but 27 per cent of that harvested from plats given a complete fertilizer. Where consistent fertilizer practices were followed good crops of thrifty trees resulted. With few exceptions the fertilization that resulted in the heaviest yields of fruit also produced the largest trees, although the effect of fertilization on the tree was less marked. In the fertilized plats the need of a complete fertilizer is decidedly proven. While the effect of complete and incomplete fertilizers on the wood and leaf growth was not so marked as on the production of fruit, in each plat given an incomplete fertilizer the leaves were smaller, and in most instances had poorer color than where a complete fertilizer was given. The yield of fruit was in every case heavier where complete fertilizer was applied. In one orchard where the number and weight of the fruit harvested was recorded the yield of plats given complete fertilizer showed a gain of 80 per cent over those given incomplete, and in the other 44 per cent. Where nitrogen was omitted from the complete fertilizer the yield was poorer than where either potash or phosphoric acid was omitted. Omitting phosphoric acid resulted in lighter yields than omitting potash. The results of the experiments indicate that for the red loamy rolling lands on the north side of the island phosphoric acid should be applied as liberally as potash. A formula providing for 3 per cent nitrogen, 12 per cent phosphoric acid, and 12 per cent potash is recommended.

---

[1] Porto Rico Sta. Bul. 18.

COCONUTS.

The coconut cooperative experiments, including fertilization and culture, reported on the past two years, have been continued and new cultural experiments undertaken in parts of the island where different weather conditions prevail. As this is a profitable crop, and one to which but little experimental attention has been given in Porto Rico, it is the plan to extend the lines of work already undertaken, including fertilization, seed-nut selection, and nursery and orchard culture. In the fertilization experiments started in June, 1912, eight harvests have been made. The number of nuts taken from each tree and the diameter of the nuts from the different plats have been recorded for each harvest. The yield in the plats given complete fertilizer was in excess of that in check plats for the last harvest, although between the complete and incomplete and check plats but little differences have resulted so far. The number of nuts harvested in the experimental field hardly averaged 30 per tree. The average diameter of the nuts was 4.8 inches. As the trees under observation are old palms on sandy beach land, apparently an ideal situation for coconut culture, the results of the harvests show how slowly old palms give returns for fertilizer investment. As the yield per tree is far below what it should be, an early increase is expected in the fertilizer plats.

Aside from the notes on fertilization, valuable data have been recorded regarding the number of nuts harvested from the individual trees. A few trees are bearing over 100 nuts per year, exceptional ones over 140, while a number, which are from all appearance thrifty, are producing annually not more than 10 nuts each, and a few not more than 5 nuts each. As there is a good stand of trees in the experimental plats, and productive and unproductive ones are found growing side by side throughout the field, the importance of seed-nut selection by those contemplating a new grove is plainly shown. In connection with selection work, records are being made showing the constancy in shape and size of both husks and nuts borne by individual trees.

In cooperation with A. J. Harvey, experiments are being conducted on his plantation to determine the advisability of growing leguminous cover crops in a young coconut grove. This plantation is situated a few miles east of San Juan on a sandy coastal plain within half a mile of the ocean. (Pl. II, figs. 1 and 2.) Jack beans (*Canavalia ensiformis*) and a few species of velvet beans (*Stizolobium* spp.) planted in April all made good growth; and as they crowded out all native weeds and grass, cultivation was dispensed with, except for cutting the leguminous vines near the palms every few weeks, until the plants died in the following winter. The Stizolobium species proved to have a longer growing season and to produce a heavier crop of vegetation than the Canavalia, and are, therefore, preferable in coconut plantations. The type of land suitable to coconut culture, if not cultivated, will, for most of the year, be overgrown with wild vines and weeds. These wild vines are almost as troublesome as the Stizolobiums in climbing over the young trees, and they store no nitrogen from the air and add much less vegetable matter to the soil. Coconut palms should be set farther apart than other orchard trees, and the cultivation of this large area and the improvement of the soil can be greatly facilitated by the judicious use of leguminous cover crops.

LEGUMINOUS COVER CROPS.

The experiments with leguminous cover crops and their value for planting with different crops have been continued and extended. A report on this work is being prepared for publication. Tests with a number of species were conducted in citrus orchards and pineapple plantings on heavy land and on sandy soil devoted to coconuts at Mayaguez and in citrus groves and coconut plantations on the north side of the island. Much of the work was with velvet-bean species, which have lately come into prominence as green manures in Porto Rico. The species under observation, aside from the well-known Florida velvet bean (*Stizolobium deeringianum*), are the Lyon bean (*S. niveum*), *S. aterrimum*, two varieties of *S. velutinum*, and *S. cinereum*. These crops have made an excellent growth in both heavy and light soils where rainfall has been sufficient. They are vigorous climbers, and when planted in citrus orchards or newly set coconut groves demand frequent cutting back to keep them from injuring the trees. They are ideal crops for “ resting ” land, as they keep down wild vegetation and greatly enrich the soil. As they live longer than cowpeas and make a heavier growth in sandy soil than either cowpeas or sword beans, they are more valuable for planting on coconut plantations. For reclaiming land or planting in groves as a cover crop or manure crop a choice of the species above mentioned may be made according to the length of season the planter wishes his field to be left uncultivated, for there is considerable difference in the length of growing season required for maturity of the different Stizolobiums, and their vining habits make cultivation impracticable.

FIG. 1.—COCONUT PLANTATION, BOQUILLAS.

FIG. 2.—COCONUT FERTILIZER PLATS, BOQUILLAS.

The Florida velvet bean was the first of the Stizolobiums to be planted in a commercial way in Porto Rico. It requires the shortest season for growing to maturity of any of the velvet beans grown here, and has for that reason not been found as desirable for planting on pineapple or cane lands being reclaimed or among young coconut trees, where a heavy crop of vegetation is desired and where the expense of cultivation must be reduced to the minimum. Spring plantings of this crop on both heavy and light soils matured in about five months, and the drying vines were soon overgrown by wild vegetation. The Lyon bean, which produces a heavier vine crop and is a more vigorous climber, matured a month later than the Florida velvet bean. It is an excellent six-month crop. *S. aterrimum*, a species with black, shining seed, which has been distributed to many parts of Porto Rico, is still later in maturing than the kinds discussed above. It is one of the heaviest and most rampant growers tested here and the vines do not die until over eight months after planting. At 6 months and 20 days after planting the green weight of this species, including vines, leaves, and seed clusters, was 16 tons per acre. The dry weight after thoroughly sun drying was 4.3 tons. This species is one of the heaviest seeders. *S. cinereum*, while living somewhat longer than the last crop mentioned, is not as heavy a grower and is not a prolific seed producer. Two varieties of *S. velutinum*, one (S. P. I. No. 24424) which bears seed which are reddish gray marbled, with black in color, and the other (S. P. I. No. 24657) which bears gray seed marbled with black, have proved to have the longest growing season of any of the species tested here. They ripen at the same time and about three weeks later than other kinds. Variety No. 24657, which thus far seems to be the more rank grower of the two, produced a crop somewhat heavier than No. 24424. The late maturing kinds do not grow as rapidly at first as the common velvet bean or Lyon bean and do not cover the ground as quickly.

The experiments in growing leguminous cover crops and in testing the effect of shade trees on pineapples were concluded during the year. The results obtained did not differ materially from those reported in 1913. Both jack beans and pigeon peas were injurious to the two varieties of pineapples under observation—Cabezona and Red Spanish—when planted in the beds with them. The pigeon pea caused the most marked injury and the Cabezona variety was more severely injured than the Red Spanish.

The pineapple varieties just mentioned, with Egyptian Queen, Ruby, Black Jamaica, Trinidad, Smooth Cayenne, and Curaçao, were planted over two years ago in the area between 7-year-old *Pithecolobium saman* trees to test the effect of the shade and the nitrogen stored in the soil by the leguminous trees on the development of the pineapples. The shade trees are growing 20 by 20 feet apart. Although the shade furnished by these young spreading trees was thin and the nodule growth on the roots very heavy, the pineapples were almost a complete failure. They suffered most during the dry winter months, when the trees no doubt robbed them of much of their required moisture. The conclusion reached in the work with growing leguminous crops with pineapples is that clean culture is necessary for the best development of pineapples.

Selections from a large number of legumes growing wild in Porto Rico are being tested to determine their value as cover crops. Many of these species are vigorous growers, have a long growing season, and have an advantage over many cultivated legumes of reseeding themselves.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McCLELLAND.

COFFEE.

The station has at one time and another imported many varieties of foreign coffee. Some of these come into bearing much later than Porto Rican coffee; some produce a larger, others a smaller, bean; some are of excellent quality and others inferior. Of these many types the planting of some is to be recommended and of others discouraged.

The planting of Mocha coffee on a commercial scale is not recommended. The quality is excellent, but the cherries are so small that the number contained in a given measure is nearly double that of Porto Rican coffee, and this alone would double the cost and difficulty of the picking.

As to vigorous growth and amount of yield, the Columnaris coffee is the most promising of the foreign coffees which have been tested on any scale and which have come into bearing up to the present time. It originated as a sport from the ordinary Arabian type and was discovered in Java less than 30 years ago. Its cup flavor is excellent. At four years from setting the yield of an extensive planting averaged about a pound per tree, and had the more favorably located trees only been considered, the rate would easily have been double this. The tree is more vigorous and grows taller than the typical Porto Rican coffee, and it may be necessary to resort to topping to facilitate picking. The bean is a trifle smaller than the Porto Rican, which is a slight market disadvantage.

The comparative sizes are shown by the 1,000-bean weight. One thousand normal, flat beans were selected from a very representative lot of market coffee—that is, coffee dried and with the parchment removed. These were then dried for more than five hours in an oven at about 105° C. The Porto Rican coffee after oven drying weighed 162.9 grams and the Columnaris 159 grams, while the Mocha weighed only 83.6 grams; or, expressed in percentages of Porto Rican weight, Columnaris equaled 97.6 per cent and Mocha 51.3 per cent. Samples of Padang coffee and Maragogipe ran larger than the Porto Rican, weighing, respectively, 116.9 per cent and 171 per cent.

Tests were also made of the comparative 100-bean weights of peaberry and flat bean. In samples of three varieties the peaberry ran larger and in three others ran smaller than the flat bean, showing a very small average difference in weight.

The coffee-fertilizer experiments are continuing to show interesting results. In one experiment with more than a hundred trees the yield of the plat which had received complete chemical fertilizer and stable manure was more than 36 per cent greater than that of the check. Very interesting and valuable data are being accumulated, but as yet the experiments do not show that fertilizer can be applied with a financial gain. Further work should show whether or not one or more elements may be omitted and what quantities may be profitably applied. Work previously outlined is being continued and new plats have been laid off for fertilizer tests, which will help throw light on these questions.

It seems quite probable that coffee should be included among the acid-tolerant plants, as benefits from lime alone applied to the acid soils here at the station have been doubtful. In some instances there has been a very slight increase in height or yield over the check, while in one experiment the plat which made in the year the least growth of any was the one which had received the most lime, a little less than 2 tons. It is worthy of note that some of the handsomest coffee trees in the station plantings are in soil which is so acid as to require 1.0527 grams of sodium hydroxid for neutralization of 1 kilogram of soil.

Damage to the coffee by rats was reported from various sections of the coffee district. These depredations occur in the spring when there is an abundance of sap running. The preference is generally for the growth which should produce the coming crop, very little of the older wood being injured. Uprights from less than pencil thickness to half an inch in diameter are gnawed nearly through, the gnawing extending from a fraction of an inch to a foot or more along the stem. Some branches are bitten off entirely and others are left hanging. Frequently the lateral branches are broken so close to the upright that no buds are left from which other laterals may be produced. As the trees attacked are widely scattered, the cost of poisoned sprays is prohibitive and other means, such as dogs, traps, and poisoned bait, must be resorted to.

From a young coffee tree with some limbs bearing variegated foliage and others normally green leaves the seed were planted to watch the inheritance of variegation. Of 30 seedlings from limbs with variegated foliage 17 had variegated cotyledonous leaves and 2 more were slightly off color, while of 36 seedlings from limbs bearing normally colored leaves none were variegated. As the tree develops and more seed become available this study will be continued on a larger scale.

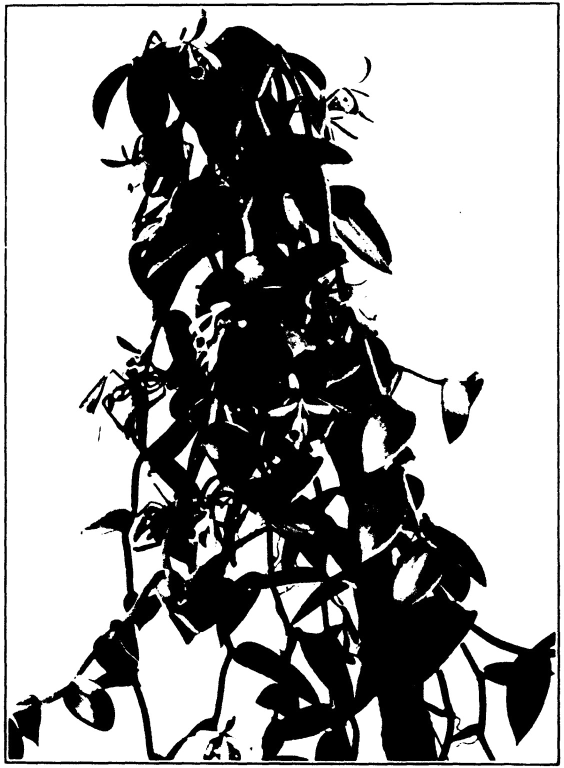

FIG. 1.—VANILLA IN FLOWER.

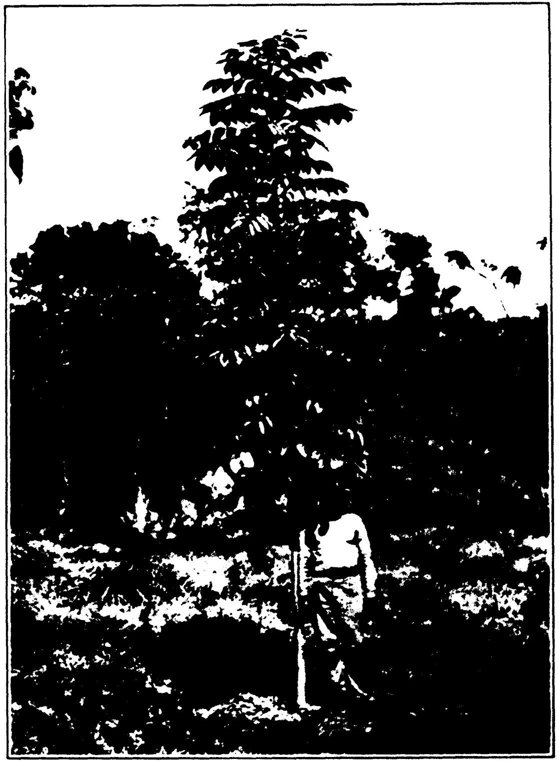

FIG. 2.—MAHOGANY TREE 2 YEARS OLD.

In cooperation with the college of agriculture, farmers' institutes for coffee planters were held in various towns in the coffee district, and such facts as had been brought out by the station's work and which the planters might find of value were presented.

As heretofore, very numerous requests for coffee seed were filled and some distribution of coffee plants was made.

CACAO.

The yield of the 11-year-old cacao planting has shown an increase of nearly a third over that of the preceding year, and was more than two and a half times as great as the crop of three years ago. The most productive tree yielded the equivalent of about 4 pounds of dried beans, worth 14 cents a pound. From weights of dried beans from more than 1,800 pods from the station plantings it was found that for a pound of unwashed dried beans an average of 11.13 pods were required. Exact data, lacking heretofore, on yields of such minor crops assume more importance, now that an interest in a more diversified agriculture has been stimulated by threatened reductions in the value of several staple crops.

VANILLA.

Of 19 cuttings of *Vanilla planifolia* started in 1912, two blossomed this spring. Most of the cuttings have made excellent growth and the vanillery is in a very promising condition.

Vanilla sp., "Pompon" (S. P. I. 14440), from Vera Cruz, Mexico, which has for four seasons shown itself sterile to all pollen from the same plant, was this season fertilized by pollen from *V. planifolia.*

Some of the vanilla species produce very handsome flowers, which, aside from all economic reasons, are well worth cultivating as ornamentals. One of the handsomest of these is a very thrifty Panama vanilla with large yellow blossoms. (See Pl. III, fig. 1.)

MISCELLANEOUS.

Monthly tappings of rubber are being continued, but the yields are so small as to discourage any plantings. The cost of tapping and collection alone has exceeded the value of the product.

Among plants of economic value obtained on a trip to Venezuela in 1913 several have shown themselves to be of unusual promise. A black bean, which is there a common staple but is not known here, is very vigorous and prolific. A very delicious table corn, which is something rarely found in Porto Rico, has shown itself fairly well adapted to some local soils. This corn, which is called "Cariaco," was said to be the best grown in Venezuela. Extensive plantings have been made of both the black bean and the corn to furnish seed for distribution.

Seedlings of mahogany, *Swietenia macrophylla*, have made exceedingly rapid and vigorous growth. One specimen at less than 17 months from seed measured 11 feet high (see Pl. III, fig. 2). There are many places accessible to roads which could be profitably planted with this valuable timber, which shows itself so well adapted to Porto Rican conditions.

The work with vegetables from seed brought from the north and grown in Porto Rico from one to many generations has been continued. Above everything else the marked effect of the planting season has stood out clearly. A tropical climate does not mean the ability to disregard the seasons.

REPORT OF THE PLANT PATHOLOGIST.

By G. L. Fawcett.

INTRODUCTION.

Various lines of work have been carried on during the past year, some of which are sufficiently complete to be mentioned in this report. Among these were the tests of the relative efficiency of the numerous ready-made preparations of Bordeaux mixture as compared with the freshly applied homemade mixture. These preparations are coming to be used quite extensively now that the grower has found that Bordeaux mixture can be used safely if applied with due regard to the weather conditions and the prevalence of scale. In making the tests coffee trees, some of which were infested with the surface-growing fungus of the leaf rot, were used, there being no citrus trees available. The sprays tested included the real Bordeaux mixture, a powder consisting of quicklime and copper sulphate, a Bordeaux paste prepared by one of the island planters, and a similar preparation from the States. These were used in equal concentration as nearly as could be estimated. The results, four weeks after the application, indicated that the fungus growth had been stopped in every instance, the fungus being apparently killed. With respect to fungicidal properties, as tested on this organism, there seems to be no difference in the value of the sprays. During the period of the test there had been but little rain. With more rain the results could well have been different, since the adhesive qualities differ markedly. This was shown by placing cacao leaves, which had been equally sprayed, under a spray of water for equal lengths of time. The ones on which the homemade preparation was used lost but little, those having received the freshly mixed powder being next best in this regard. The imported paste adhered less well than the others, being nearly all removed.

It is well known that fresh homemade Bordeaux mixture is somewhat different chemically and physically from the same preparation if allowed to stand some hours, when it becomes equivalent to the ready-made preparations. In these the division of the particles of the lime-and-copper salts is less fine, and they tend to adhere less well when applied in the spray. It is probable, however, that enough fungicidal properties are retained to control the fungi affecting citrus trees, as well as that of the coffee leaf rot, if not washed off too soon by rain and dew. One paste used to some extent by the growers but not tried in the tests seems to adhere very well. Possibly it contains some substance other than lime or copper to cause this.

The tests have shown nothing to indicate that the homemade preparation should not be used in place of these articles, since it is usually more efficient as well as cheaper.

COFFEE DISEASES.

Some tests were made as to the resistance of the foreign varieties of coffee to disease. *Stilbella flavida* was used first, inoculations being made at the same time on the leaves of *Coffea arabica* as checks. On the Robusta coffee (*C. laurentii*), especially well known because of its resistance to *Hemileia vastatrix*, it took readily, fruiting on the veins. On *C. liberica* and *C. abeokuta*, nearly related varieties, it has not taken well, the inoculation resulting in small wounds which healed over with suberized growth. The inoculation on *C. stenophylla* formed large spots which fruited freely. Those on *C. canephora* resulted in the formation of spots which fruited, but the fungus has not spread. On the checks *C. arabica* and on the closely related variety *C. arabica columnaris*, the fungus took readily, having spread to other trees. As *C. perieri* had already shown itself so subject to the disease, it was not used in the inoculations.

Little difference in the resistance to this fungus would be expected in these species of coffee, as it is capable of infecting and fruiting on plants belonging to widely separated families. Nevertheless, there seems to be decided differences. Even where it took well, as on *C. laurentii*, it acted much more slowly than on *C. arabica.* These differences are partly due, probably, to the fact that the habit of the trees with regard to distribution of the foliage varies, those species with large leaves, somewhat farther from each other, offering less favorable conditions than those with more numerous and closely set leaves, which renders distribution from leaf to leaf more easy and also tends to favor a stiller, more humid atmosphere. Another leaf character favoring the development of the spot is the closer venation. The spots develop noticeably better when in contact with a large vein and always fruit earlier when so situated. In some species, notably *C. abeokuta*, *C. liberica*, and *C. canophora*, the venation is not close. Other slight nonapparent differences in the chemical composition of the leaf may influence the result as to this point.

The inoculations with *Pellicularia koleroga* have taken well on the Robusta coffee, killing the leaves. Similar results have been obtained with those made on *C. stenophylla* and *C. abeokuta.* The Liberian coffee can hardly be expected to resist better than the *C. abeokuta. C. canephora* seems to take the fungus less readily. On the checks *C. arabica* and on the variety *columnaris* the infection resulted much sooner than on the other species. Whether the fungus will be able to establish itself permanently on these recently introduced trees as on the native coffee remains to be seen, but it is probable that it will do so. A tree on which this does not happen in spite of infection would be really resistant.

No doubt the habit of growth, which favors the Stilbella, also favors this fungus. Where the pairs of leaves are close together it has smaller distances to pass along the stem between the sources of food supply. It is certain that most of the species worked with must possess some degree of resistance and are less easily infected than the native coffee. It is probably this quality which has enabled trees of *C. abeokuta* to remain free from the leaf rot, although surrounded by diseased trees.

It is improbable that these foreign coffees are so superior to the native coffee in both quantity and quality as to justify their being grown in place of that coffee. However, if a tree could be found even somewhat inferior from the standpoint of yield, its cultivation would be advisable in those places where the diseases are most prevalent. This applies especially to the "mancha de hierro." There is now no other practical solution of the problems presented by this disease and that due to *P. koleroga.* If such trees can not be found, or, if being found, they are not made use of, the conditions with respect to these diseases will remain as at present.

CACAO DISEASES.

A new fungus disease of cacao has been noted. The fungus is apparently a species of Corticium, but as no fruiting condition has been found and the vegetative characters are reported[1] to be different from those of *C. lilacino-fuscum*, no identification has been made. It covers the branches with a close pinkish growth which, when old, becomes white. It makes its first appearance at the lenticels of the branches, but only after it has attacked and killed the underlying tissues. It is extremely parasitic, differing in this also from the description of *C. lilacino-fuscum.* The attacked branches are invariably killed. In pure cultures, which may be obtained from the diseased tissue next to the still healthy material, it fails to take when inoculated into healthy tissue. In spite of this, its parasitism can hardly be doubted, since it occurs alone in the newly attacked tissue, and because its presence always marks the death of the branches. It also attacks and kills coffee-tree branches, and was found to be decidedly parasitic on grapefruit branches, although it has been found but twice on that tree. On coffee it is known only on a small group of trees in one plantation. The distribution of a fungus which on its known hosts is always sterile is of interest. It occurs usually on the branches, often well up in the tree and in well-located patches. The best explanation of its distribution is that it is typically a ground fungus, but ascends to the branches through the dead vines so common even in well-tended plantations. On the grapefruit it has been noticed connecting by mycelial growth the dead branches and an adhering vine. It is more probable that it passed from the vine to the tree than otherwise, since the diseased area did not extend far from the point of contact with the vine.

---

[1] Dr. F. J. Seaver, New York Botanical Garden, in letter.

The control of the parasite will be found, no doubt, to be simple, consisting in the pruning out of the diseased material and the removal of all vines, dead as well as living, from the trees. Their presence, in any event, can not but result in injury to the trees.

A disease of cacao very troublesome in most countries is the canker now generally conceded to be caused by the Phytophthora that causes the black rot of the pods. In Porto Rico the writer has found no really injurious disease of this nature, although occasionally there are to be found wounds on the trees which answer closely to those described for the real canker, the discoloration of tissue and exudation being apparently the same in both diseases. It is probable, however, that the symptoms could be the same even if the trunk were attacked by very different organisms. In Porto Rico *Phytophthora faberi* has never been found in this or other cacao material, but *Spicaria* (*Fusarium*) *colorans* is always to be isolated from the diseased tissues. Inoculations with pure cultures of the fungus do not take, the wounds healing vigorously under the material used in the inoculation. To produce a canker wound it seems clear that some severe wound or the continued attacks of insects, such as the common borer, is necessary. The Spicaria may take some part in the production of the trouble, but, so far as the Porto Rican canker is concerned, it is practically a question of avoiding the insects or of the breaking of the trees caused by the fall of palm leaves. The wounds so made apparently enable the somewhat parasitic fungus to get well started; healing is retarded and a canker is observed long after it has become impossible to say what the real cause of the trouble may have been.

DISEASES OF CITRUS TREES.

The disease of these trees given most attention was the black rot of the fruit (*Diplodia natalensis*), which causes notable losses to the fruit in shipment. The fungus has been found to fruit only on the branches, where it causes a dying back under certain conditions. The fruit has been found to be infected in the groves before being picked, and the fungus spreads but little from diseased to healthy fruit in the packed boxes. Sufficient data were obtained to indicate a rational method for its control. The principal results of this work have appeared in a local publication.[1]

Work has been done with the diseases of banana and other fruits, the results of which will be given in separate reports.

---

[1] Porto Rico Progress, 8 (1914), pp. 5, 7.

REPORT OF THE ENTOMOLOGIST.

By R. H. Van Zwaluwenburg

INTRODUCTION.

Between the date of the death of the former entomologist, Dr. Charles W. Hooker, February 12, 1913, and October 16, 1913, the only work carried on in this department was with honeybees. The entomological collection has been materially increased and the very comprehensive note system begun by Dr. Hooker has been maintained. Much of the recorded work on hand in October had to do with life histories and habits of important insect pests, and some of it had already been well advanced. All of this work will be continued as steadily as possible.

As usual the most troublesome pests on the island have been the changa, shot-hole borers, and ants, and no important advance in methods of control of these insects has been made. May beetles and the sugar-cane root and stalk borers have been as important as ever in the cane district. In the Mayaguez section there have been outbreaks of the chiva (*Megalopyge krugii*), damaging guamá and coffee foliage; of the common cucumber beetles, *Diabrotica innuba* and the smaller, *D. bivittata;* and of shot-hole borers (probably *Xyleborus* sp.), which have killed numbers of guamá trees (*Inga laurina*). During the winter months the diamond-back moth (*Plutella maculipennis*) did some damage to cabbage, but was reduced to unimportance when the heavy rains began. There was a local outbreak of *Melanchroia cephise* in Camuy, where the larvæ practically stripped the grosella trees (*Phyllanthus distichus*). A round-headed borer (*Apate francisca*) is very numerous about Mayaguez and has 10 recorded host plants. It has been taken in living *Salix humboldtiana* and in dry posts of palo de hueso (*Picramnia pentandra*).

The principal work of the past year has been with the pests of coffee and coffee shade trees, with miscellaneous insect enemies, and with a bacterium pathogenic to May-beetle larvæ. A preliminary check list of Porto Rican insects has been prepared for the use of working entomologists on the island.

THE CHANGA.

Many remedial measures for the control of *Scapteriscus didactylus* have been tested at the station. Of these, one gives promise of satisfactory results. This is the strewing broadcast over infested areas of "funche," the phosphorus and corn-meal mixture used on cane plantations against land crabs. Although remarkable results have not been obtained with this method in Mayaguez, it is said to be very effective on an estate on the south coast. Needless to say, this remedy is dangerous in the presence of poultry.

The life history of the changa is at present being worked out in detail, and it is expected that something of value concerning this pest can be offered later.

COFFEE LEAF MINER.

The coffee leaf miner (*Leucoptera coffeella*) is abundant in all the coffee-growing sections of the island, and, although never causing the death of even young trees, it makes a heavy drain upon the vigor of the plants. Coffee is the only known host plant of this insect. The pest is in all probability a native of the West Indies, whence it has spread to the South American mainland.

The adult is a minute silvery white moth measuring about 2½ millimeters when its wings are closed. The outer margins of the wings bear yellow hairs, which give a dirty yellow appearance to the end of the body when the insect is at rest. The moth usually rests on the underside of leaves and is easily disturbed, moving with a swift, jerky flight. In the laboratory adults have been kept alive four days.

The eggs of the leaf miner are laid singly and unprotected on the upper surface of the coffee leaf. The egg is oval and pearly white; it measures about 0.33 millimeter long and 0.25 millimeter wide. The sides of the egg slope upward sharply and the greater part of the surface is occupied by a boat-shaped depression. The egg stage averages slightly less than five days in the winter months, although during April it is four days, according to Dr. Hooker. The young larva makes its way through the base of the egg directly into the leaf tissue, where it begins to feed almost at once. The eggs are most commonly placed beside or near a vein of the leaf, but may be found on any part of the upper leaf surface except very near the tip or base. The number of eggs laid by a single female is not known.

The larva passes all its time within the mine and in from 11 to 13 days, when full grown, it is between 4 and 5 millimeters in length. The body is dorso-ventrally flattened and tapers from the head backward, with a slight increase in width at the first three abdominal segments. Normally there is one larva in a mine, but when the feeding galleries cross and merge as many as seven larvæ have been found together.

When the larva is full grown it makes a small slit in the upper surface and crawls to the underside of the leaf to pupate. The pupa case is about 5 millimeters long and is made of a white silk secreted by the larva. A few hours after spinning up the pupa is formed within its case and the adult emerges in six to eight days.

The Liberian coffee seems to be free from serious attack by the leaf miner. The eggs are laid on its leaves commonly enough, but after feeding a day or two, making a very small mine, the larva dies, due either to the toughness of the leaf tissue or to the absence of proper food. In many cases the larvæ are unable to gain entrance into the leaf from the egg. The mines in Liberian coffee have a peculiar embossed appearance quite unlike the normal flat mine in the leaves of Arabian coffee.

The coffee leaf miner in the larval stage is parasitized by two chalcid flies, *Chrysocharis livida* and *Zagrammosoma multilineata*, the former being especially abundant in the Mayaguez district. During the spring fully 30 per cent of several hundred occupied mines inspected in the station coffee planting contained pupæ of *C. livida.*

Spraying infested trees with one pint of nicotin sulphate in 100 gallons of water containing 5 pounds of soap in solution is effective against the pupæ if applied with considerable force to the undersides of the leaves, but the results will not repay the expense and labor involved. Any mechanical treatment will be impractical in a commercial coffee planting where the unevenness of the land makes work slow and expense high. A similar mixture with 29 fluid ounces of nicotin sulphate in 100 gallons of soap solution gave no practical results. Less than 15 per cent of the larvæ in the mines succumbed and the eggs were unaffected.

Anything, such as cultivation, for example, which will render the coffee trees more vigorous will help them to offset the attacks of the insect with strong and healthy growth.

COFFEE SHADE PESTS.

The most troublesome insect of coffee shade trees during the past year has been the shot-hole borer (probably *Xyleborus* sp.) working in guamá and guava (*Inga laurina* and *Inga vera*, respectively). These two trees are the favorites for shading plantations of coffee; the only point against them seems to be their susceptibility to insect attack. In some of the hill districts whole areas of guamá are killed by the shot-hole borers, and the coffee beneath exposed to the direct rays of the sun. The control of the insect, therefore, is a serious problem for the coffee growers. As far as the writer knows, nfested trees recover only occasionally, and then only from very ight attacks; it is, therefore, important to stamp out the insect at ts earliest appearance. Trees should be felled and converted into harcoal as soon as the beetle is found to be present.

The undetermined pink Coccus attended by *Myrmelachista ambigua ramulorum* on the branches of guamá is very troublesome, and when it spreads to coffee it becomes one of the worst pests of that crop, due to the weakening of the branches and the destruction of new growth. The removal of all the infested branches from isolated trees at the station a few years ago has been a success, although a close inspection of the trees is necessary from time to time. Banding trees with Tanglefoot, offering poisoned baits, and similar remedies have been unsuccessful in ridding trees of the attending ant.

The larva of a "flannel moth," *Megalopyge krugii*, known locally as the chiva, has been very abundant on guamá, causing considerable damage to the leaves. Occasionally coffee is also attacked, especially the Liberian variety. The larva is covered with long white hairs and is provided with brittle spines which cause a burning sensation if allowed to come in contact with the skin. The pupa case is a very common sight on the trunks of guamá; it is oval, with a "trap-door" exit at one end. The very tough case measures 16 by 10 millimeters and is formed of the hairs of the larvæ mixed with a substance secreted by the mature larva. The chiva is very commonly parasitized by an undetermined tachinid fly and by *Chalcis ovata*. The latter is very abundant at times, and it undoubtedly serves as an important check on this pest.

MAY BEETLE.

During the past year some work was done with a bacterium pathogenic to Lachnosterna larvæ. This bacterium has been described as *Micrococcus nigrofasciens*. The results obtained here with cultures of this bacterium were unsatisfactory, for the larvæ in check cages showed almost as high a percentage of mortality as those in the inoculated cages. However, it developed later that the bacterium is native to Porto Rican soils and is apparently widespread. The disease in Lachnosterna is confined to the larval stages, and is characterized by a blackening of the parts affected. The organism is present in our soils, but its efficiency can not be increased by any practical means, for infection takes place usually only through a bruise or cut in the integument of the larva.

MISCELLANEOUS PESTS.

The brown "woolly bear" caterpillar (*Ecpantheria eridanus*) was fairly common on orange trees in the Mayaguez district. The spherical lemon-yellow eggs are laid on the leaves in an irregular mass, containing 500 or more and hatch in 6 to 8 days. The larvæ are voracious feeders and come to maturity in about 5 weeks after hatching. Pupation takes place in a loose web of brown silk and requires about

17 days. In addition to the orange, the larvæ feed on the leaves of banana, bucare, and sweet potato.

The small sweet-potato weevil (*Euscepes* (*Cryptorhynchus*) *batatæ*) made its appearance in the station planting during the winter months. This insect prefers a dry, light soil, and will then increase rapidly. Sweet potatoes should not be left in the ground after they are full grown, but should be gathered as soon as possible. Neither should they be planted in soil which was infested the season before.

Silk oak trees (*Grevillea robusta*) are often severely attacked by the fringed scale (*Asterolecanium pustulans*). This is a sulphur-yellow scale which forms pitlike depressions on the twigs and small branches; it is common throughout the island. A lime-sulphur spray repeated after two weeks will control this insect.

Some damage to tobacco seed pods by the boll or false bud worm (*Heliothis obsoleta*) was noticed in plantings at the station. Corn is the preferred food plant of this insect, but tobacco and tomatoes are attacked also as the corn comes to maturity. If otherwise possible, tobacco should not be planted near fields of corn. Seed pods may be protected by bagging with light cloth. This insect also attacks the tobacco buds and may then be controlled by sprinkling an arsenate of lead and cornmeal mixture on or into the buds.

The most common large weevil of the island and at the same time one of the most important is *Diaprepes spengleri*. This is the snout-beetle, called the "orange leaf weevil" by the citrus growers and the "weevil root borer" by the cane planters. The adult has a great variety of host plants and the larvæ have been reared on the roots of cane, orange, and sweet potato. On citrus trees the eggs are laid in groups of 20 to 150 on the upper leaf surface and are protected by gluing another leaf over the cluster or by fastening over a portion of the same leaf. The eggs are white and cylindrical in form; they measure about 1 millimeter in length and 0.33 millimeter in breadth. Upon hatching, the young drop from the leaf and enter the ground, where the rest of their development takes place. The attacks of the adult are not often serious, but in case they do become so on citrus trees, they may be controlled by arsenical sprays.

HONEYBEES.

In an effort to improve the strain in the station's apiary all crossed queens have been replaced by tested Italians, most of them imported. The sale of nuclei has been discontinued. There are now several queen breeders in the island, and it no longer is necessary for the station to provide beekeepers with nuclei.

○

Issued November 23, 1916.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Agronomist in Charge.
Mayaguez, P. R.

REPORT OF
THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1915.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

DEC 18 1916
UNIV. OF MICH.
LIBRARY

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1916.

Issued November 25, 1916.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Agronomist in Charge.
Mayaguez, P. R.

REPORT OF

THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1915.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1916.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

D. W. MAY, *Agronomist in Charge.*
P. L. GILE, *Chemist.*
E. W. BRANDES, *Plant Pathologist.*
C. F. KINMAN, *Horticulturist.*
R. H. VAN ZWALUWENBURG, *Entomologist.*
T. B. MCCLELLAND, *Assistant Horticulturist.*
J. O. CARRERO, *Assistant Chemist.*
C. ALEMAR, Jr., *Clerk.*

LETTER OF TRANSMITTAL

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., April 1, 1916.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1915.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service.
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

Page.
Summary of investigations 7
  General conditions 7
  Agricultural labor 9
  Fertilizing elements 10
  Live stock 11
  Forestry 12
  Cooperation 12
Report of the chemist and assistant chemist 13
  Introduction 13
  Analytical work 13
  Bat guanos 13
  Lime-induced chlorosis 14
  Recommendation for future work 15
  Fertilizer experiments with sugar cane on the red-clay soil 16
    Introduction 16
    Results of fertilizer tests 16
      Experiment at Hacienda Trinidad 16
      Experiment at Hacienda Altagracia, field 3 18
      Experiment at Hacienda Altagracia, field 19 20
      Experiment at Hacienda Cipriano, field 19 21
    Discussion of results 22
    Summary 23
Report of the horticulturist 25
  Coconuts 25
  Mango 26
  Vegetables 27
  Miscellaneous introductions 28
Report of the assistant horticulturist 30
  Coffee 30
  Cacao 32
  Vanilla 32
Report of the plant pathologist 34
  Experiments in the control of a banana disease 34
  Miscellaneous experiments 35
A Porto Rican disease of bananas 36
Report of the entomologist 42
  Insects attacking coffee and coffee shade 42
  Garden pests 43
  White ants or comejenes 43
  The rhinoceros beetle of coconuts 44
  Miscellaneous pests 44

ILLUSTRATIONS.

Page.

PLATE I. Fig. 1.—Totafari mango. Fig. 2.—Alphonse mango............... 28

II. Fig. 1.—Robusta coffee in flower. Fig. 2.—Robusta coffee in fruit. 28

III. Fig. 1.—Chamaluco banana in last stages of disease. Fig. 2.—Section of banana trunk showing diseased areas.................... 36

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1915.

SUMMARY OF INVESTIGATIONS.

By D. W. May, *Agronomist in Charge.*

GENERAL CONDITIONS.

Of the 3,600 square miles of land in Porto Rico practically none is without growth of some sort. Nature abhors a barren soil. At the time of its discovery doubtless the entire island was covered with trees, as is now the area of virgin land in the highest mountains.

The utilization of the land in agriculture has proceeded in the same manner as in the States; that is, the more accessible lowlands have been cleared and planted, this area being successively extended through the foothills into the mountains. The cultivable area now may be divided into three general classes, (1) the lowlands devoted to sugar cane and grasses, (2) the hill lands formerly growing coffee but now exhausted for this crop, and (3) the mountain lands still planted to coffee but showing diminishing returns.

The lowlands are planted mainly to sugar cane with a rotation in grass. The period of resting depends upon the price of sugar, the tendency since the American occupation being to keep the lands in cane, using large amounts of fertilizer, deep plowing, and frequent cultivation to secure results that could be obtained by rotations with legumes.

Sugar production continues quite profitable, owing to good prices, large yields, and the employment of the most efficient machinery.

The coffee growers have had better prices but a smaller crop than usual during the year. While the European market has been largely shut off, there have been increasing sales to Cuba. Owing to the prosperity of that country, the people are using not only more but better grades of Porto Rican coffee. More favorable reciprocal trade relations covering coffee should be established with Cuba. Cuba could easily take the entire Porto Rican crop, as it is small and is the kind of coffee most relished by the Cubans.

The fruit crops have been good and better prices were received during the past season. There is a lessening of the area planted to fruit, but as a whole more attention is being given to the care of the plantings, resulting in larger yields and improved quality of fruit.

Cooperation has succeeded better among the fruit growers than among any other planters. They have an exchange for selling fruit and buying fertilizers, boxes, etc., and community packing houses are being built wherever the extent of the plantings justifies their erection.

The fruit industry has grown up in the hill lands which had been cut over many years before and were not at the time very productive. It has required skill and money to develop this industry, which needs constant and unremitting care. It is the only special line of agriculture of any extent that has grown up under American development. The general good it has done to the island has been great. It has developed unproductive land, given employment to labor, increased the wealth of the country, and built up communities of beautiful homes and grounds in contrast with the desolation that had before prevailed.

The growth of agriculture in Porto Rico started in the coast lands and has been carried into the interior. As in the States when land became unproductive, operations were extended to new areas. In the States agriculture extended west from the Atlantic seaboard, while in Porto Rico it extended inland. This island, however, was settled before continental America, and the lands have been exploited for a much longer time. Moreover, there has been no emigration from Porto Rico, and while the lands showed diminishing returns the population continued to increase. It is from this condition that agriculture must now extricate itself.

The low-lying coast lands will continue to be profitable, the mountain lands planted to coffee will, with care, produce many more crops, but the intervening hill lands denuded of their forests, baked by the sun, and gullied by the rains, offer a most serious problem, for such soils, forming the larger part of the surface of Porto Rico, have not only lost their natural fertility, but do not respond readily to the application of plant food. They can be made again productive, but it will take time, and Porto Rican planters are not disposed to work for a remote profit. Legumes are the hope of such soils, and these should be followed with tree crops as assuring the greater profit and more certain returns. While such areas are basically good they yield the owner practically nothing, nor can they yield anything until a system of improvement covering a period of many years is persistently carried out. They were formerly planted to coffee, but the yields of this crop decreasing in the course of time to the point of unprofitableness, the leguminous shade trees were cut down and made into charcoal, and a condition of soil sterility followed as a natural consequence.

It is these large, unplanted areas that strike the stranger as unusual. They lead him to believe that the peons whose palm-thatched cottages are scattered about are shiftless to a high degree. This is partly true, but the condition is due more to ignorance than to laziness. These peons do not know how to make a quick crop grow, and they are so destitute of the actual necessities of life that they can not consider the question of waiting for a crop which requires a long time to mature.

AGRICULTURAL LABOR.

While the natural resources of Porto Rico have decreased, the population has steadily increased until there are now 350 people to the square mile, making Porto Rico one of the most densely populated regions in the world. The problem, then, in agricultural endeavors, is to produce foodstuffs, or other crops of sufficient value to be exchanged for foodstuffs, for the maintenance of the ever-increasing population.

While the imports and exports of the island have grown, the general condition of the poorer classes has not changed in proportion. The population is increasing more rapidly than industries are developing, and, as a consequence, the standard of wages and living remains low. To arouse these people from the apathy of many generations is extremely difficult. There is little or no organization among them and competition for the lowest paid positions is keen.

It is the custom for the peons, as they are called, to build their houses on the plantation of the man for whom they work. These houses are of the crudest description, usually made of cheap boards, old packing boxes, and tin cans, with roofs of grass or leaves. They generally consist of two rooms and an outside kitchen, a table and a few chairs constituting the bulk of the furniture, the entire family usually sleeping on the floor. There is little improvement in their condition from year to year, as they have nothing to live upon but the labor which they offer in an overcrowded market. The plantations in the interior have as a rule more people living on them than they can support. These are employed for a few months in the cane fields but for the greater part of the year they are idle. If disaster overtake the cane crop the laborers must have outside aid or they starve.

With no coal or iron and little water power, manufactures have not generally flourished in Porto Rico, only cigar factories having been established on the island. Hat weaving and lace making give some employment to females. The maintenance of the people in this, one of the more densely populated countries of the world, must come mainly from agriculture.

Though there is growth throughout the year in Porto Rico, yet there are seasons when much labor is out of employment. These laborers, in order to maintain themselves during periods of idleness as well as to place themselves in a position to secure better pay, must become more independent of their daily wage. Many living in the country do not have gardens worthy of the name, and little, if any, live stock or poultry.

FERTILIZING ELEMENTS.

Where soils are depleted as are those of Porto Rico and where expenditures for fertilizers approximate $1,000,000 annually, it is advisable to seek all available sources of fertilizing elements. Phosphorus, potash, and especially nitrogen are lacking in most Porto Rican soils. The many leguminous trees and plants growing in the island are the principal source of the last element, but more recourse should be had to these plants in the system of agriculture. There are many deposits of phosphorus in caves located in the limestone regions and in Mona Island to the west. During the year, the station made extensive investigations of some of these deposits, and surveyed and mapped 103 caves in the island of Porto Rico. The caves on Mona Island have been worked at different periods for many years. At present these deposits are controlled by a company that pays to the insular government a ton royalty on the amounts extracted. Some has been used in Porto Rico, while considerable quantities have been shipped to the States. The experiment station has not yet investigated these deposits.

While these caves, like those in Mona Island, have deposits of sea bird guano, they are inhabited now only by bats. The caves are of three general classes, (1) those entered horizontally and apparently formed by separation of limestone strata, (2) sink holes (in one case 200 feet in depth) with galleries ranging from them, and (3) underground streams following natural cavities in the rock strata. They are situated in the limestone areas of the island, and vary greatly in size and extent, the largest being 450 feet deep by 90 feet wide. The deposits range from small amounts to more than a thousand tons, their physical condition differing as widely. Some are the unmodified droppings of bats, while others are caked and sometimes leached by rain water percolating through the roofs of the caverns.

Some of these deposits have already been partly used, especially where they are accessible to cane fields. While much of this fertilizing material is difficult to transport, yet it is of sufficient value to render its utilization less expensive than importation of fertilizers from other countries. The various deposits have been mapped and sampled, and further work, both analytical and cultural, will indicate their true value to Porto Rican agriculturists.

Owing to the European war it has been impossible during the year to obtain potash. The only available supply comes from tobacco stems and dust from the cigar factories. Some seaweed is deposited on the north coast during certain seasons but so far no use has been made of it as a source of potash.

On the south coast, which is almost rainless, large quantities of salt are obtained by the evaporation of sea water. The mother liquor drawn off after the sodium chlorid crystallizes out contains between

1 and 2 per cent of potassium chlorid. In southern France, where similar salt works occur, this mother liquor is used as a source of potash. On the southwest corner of the island, where salt making is now carried on, there are salt pans 150 acres in extent which are adjacent to similar land that could be utilized to increase the evaporating area tenfold.

In the manufacture of this salt the sea water is let into shallow basins during high tide by a gate at the coast line. After it is evaporated by the sun's rays to a certain concentration it is raised by windmills to the salt pans, where, after further evaporation, the salt crystallizes out. The mother liquor is then run back into the sea at low tide. The present capacity of the salt pans is about 30,000 tons of salt annually. From the by-product, the mother liquor which is thrown away, it is estimated that 1,000 tons of potassium could be recovered. This matter will be further studied, with a view to determining the feasibility of profitably using this by-product.

LIVE STOCK.

There has been a great improvement in all classes of live stock during the last few years, but there is yet much to be desired in this industry. Owing to a change in the regulations covering the use of funds from sales, the activities of the station in stock breeding have been curtailed. Cattle breeding is the only line now followed, the other stock having been disposed of. Now that there are breeders of the several lines of improved live stock it is not so difficult for those desiring pure-bred animals to secure them. In the past horse breeding has received the most attention, but now dairy stock is in great demand and cattle growing is profitable.

The island produces most excellent grasses. Corn and the non-saccharin sorghums are grown. Sudan grass, a recent introduction, is very successful on the south, or dry, side of Porto Rico, and its production is increasing rapidly. The velvet bean, while improving the soil, is also finding favor as a stock feed. Not the least of the activities of the station is the growing and distribution of these forage crops.

The cattle tick prevails throughout the island and is the greatest drawback to cattle growing. Its extermination is necessary, and could be accomplished at comparatively small expense. When public sentiment becomes aroused to the desirability of getting rid of this pest it will no doubt be eliminated.

Among the poorer classes goats are used for producing milk. Their cost is small and they subsist on the scantiest herbage. They are destructive, however, to tree growth. Cattle, when they can be afforded, lend themselves to the permanent development of the country.

FORESTRY.

The reforesting of the 200 acres set aside by the insular government on the mountain above Mayaguez has been continued by the setting of many more trees, among the more promising of which are mahogany, mango, and mamey. This tract has been bare of trees for some years and is badly washed. As it had been used as public land it was unfenced and closely grazed, and along the gullies where trees had grown best they had been cut and used by charcoal burners.

A great many trees have been propagated and sent out by the experiment station during the year. The most popular have been improved varieties of mango, mahogany, and eucalyptus, also many leguminous trees, both native and foreign.

There is in Porto Rico practically no soil that is not producing some form of plant life. It is the desire of the station to make the land produce the maximum of crops supplying the necessities and comforts of life. Soils growing only sparse grasses or worthless plants should be made to grow valuable crops. Trees having the greatest area of bearing surface will give the greatest returns per acre, and with a dense population it is necessary to use only those producing such returns. The hill lands, much of which does not yield profitable annual crops, should be planted to trees, preferably legumes, as the land so planted will yield more forage than is now obtained from the scanty herbage left by the baking sun and beating rains, while these trees will at the same time act as nurse trees for the more profitable coffee, cacao, and fruits.

COOPERATION.

The detailed work of the station is given under the reports of the various departments. Better facilities are greatly needed for bringing results to the planters, especially through cooperation with the agricultural college and the public schools. In conference, by correspondence, and through the distribution of seeds and plants cooperation is being furthered, but much more work along this line is highly desirable.

Cooperation with the insular government in the production of fiber crops, especially the weaving palms, is being continued. A plan of cooperation has been adopted whereby there is a division of labor and mutual helpfulness between this station and the insular station at Rio Piedras. The Bureau of Plant Industry, United States Department of Agriculture, has been of assistance in introducing various seeds and plants, many of which are proving valuable additions to the cultivated crops. Some of the more progressive planters are growing experimental plats of these introductions, which serve not only as tests of their value, but also as demonstrations to the farmers of the neighborhoods.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and J. O. Carrero.

INTRODUCTION.

No new problems were taken up the past year, those mentioned in the previous report demanding all the time and facilities available. Satisfactory progress was made in most of the investigations, and some will be completed soon. The fertilized plats of sugar cane on the red-clay soil were cut the past year, and the results of the tests are reported below.

ANALYTICAL WORK.

All the analytical work was devoted to the various investigations mentioned. The analysis of some 50 samples of plant ashes and 200 samples of guano constituted the larger part of this work, although a number of miscellaneous samples were analyzed and many determinations were made of the soluble iron in various nutrient solutions.

BAT GUANOS.

Considerable progress was made in the study of bat-guano deposits, and it is expected that the work will be virtually completed by the end of 1916.

Some 200 samples of guano were analyzed for nitrogen and the three forms of phosphoric acid. Seventy-five of these were tested once or several times in experiments with corn and millet to determine the availability of the phosphoric acid for plants. This gave a check on the availability of the phosphoric acid as determined by the solubility in neutral ammonium citrate. Some experiments were also conducted to determine the effect of different soils on the availability of the guanos as compared with acid phosphate, bone meal, and basic slag.

The results of the work thus far confirm the notes on guanos published in the previous annual reports and bring out some new facts.

The greater part of the guanos are to be considered as low grade phosphatic fertilizers; that is, they have to be used in considerable quantities to give the same results as acid phosphate or basic slag.

The percentages of total phosphoric acid found in the samples analyzed thus far range from 1 to 42 per cent. The samples containing very high percentages of total phosphoric acid generally contain little that is available, although this is not an absolute rule, as a few samples from the drier caves contain a high percentage of total phosphoric acid with more than half soluble in neutral ammonium citrate. By vegetation tests it appears that if the availability or effectiveness of the phosphoric acid in acid phosphate is taken as 100 per cent, the effectiveness of the phosphoric acid in different guanos ranges from zero to 100 per cent. With most guanos the solubility of the phosphoric acid in neutral ammonium citrate parallels very closely its availability as determined by vegetation tests with corn and millet. As phosphatic fertilizers the guanos are equally effective for corn and millet.

Most of the deposits contain but little nitrogen, although there is a small amount of material in nearly every cave, generally the first 2 to 3 inches of the deposits, that contains considerable nitrogen. The very fresh material that has undergone no decomposition may contain 10 to 11 per cent of nitrogen. The percentage of nitrogen generally decreases with the age of the deposit, or rather with the rapidity of the bacterial decomposition. A few deposits, however, have been examined that contain considerable nitrogen and yet, from their depth and extent, they must be of considerable age. These deposits, which are very wet, have probably undergone an anaerobic bacterial decomposition similar to that which results in the formation of peat. It is probable that the availability of the nitrogen in this particular class of guanos is low.

LIME-INDUCED CHLOROSIS.

As mentioned in the preceding report, it has been necessary to investigate several general or subsidiary problems before analytical and other data secured in the direct study of chlorotic plants could be properly interpreted. One of these investigations on the variation of the ash composition of rice at different stages of growth was completed and published.[1] Some of the results brought out follow:

From the analyses of withered and green parts of normal rice plants at various stages of growth, it appears that there is a regular and marked decrease in the iron content of the green straw and leaves with the increasing age of the plant. The withered straw and leaves, however, contain higher percentages of iron than the green, so that there is little variation in the percentage of iron in the ash of the whole plant after the twenty-sixth day. It is, therefore, important in making comparative iron analyses of green and chlorotic plants, where only live or functioning leaves and straw are sampled, to take into account the relative development or maturity of the plants.

---

[1] U. S. Dept. Agr., Jour. Agr. Research, 5 (1915), No. 9, pp. 357–364.

Data were also obtained on the other ash constituents, which are of less importance in the study of chlorosis. The percentages of potash, phosphoric acid, and sulphur in the ash, and of nitrogen in the dry matter decreased with the age of the plant, while silica increased. Compared with the plant at the time of flowering, the mature plant with seeds ripe contained practically the same absolute amount of all ash constituents except potash, which increased, and soda, which decreased. Previous to flowering, the percentages of dry matter in the green plant and of ash in the dry matter seem to be influenced by the effect of the weather on the growth of the plant.

A second accessory investigation of chlorosis was nearly completed the past year, consisting of a study of the assimilation of iron by rice from several nutrient solutions, using a number of different iron compounds in varying quantities. This will probably throw some light on the available forms of iron and on the factors affecting their assimilation.

A third investigation on the extent to which roots can exercise the power of selective absorption will probably be completed the coming year, satisfactory progress having been made.

RECOMMENDATION FOR FUTURE WORK.

With the installation last year of equipment for conducting vegetation experiments in pots, facilities are now adequate for carrying on certain lines of work on soils, fertilizers, and plant nutrition. The laboratory is also fairly well equipped for handling the analyses necessary to such studies. Probably the most profitable extension of the work would be a systematic soil survey combined with field experiments.

The need of a soil survey and a comprehensive series of fertilizer experiments on the different soil types is more or less patent to all familiar with conditions on the island. The great variety of Porto Rican soils, with the wide variations in rainfall, makes proper fertilization a very complex problem. Thus far the fertilizer requirements of the red clay soil for sugar cane, and of certain sandy soils for citrus trees, have been fairly well determined in certain districts, but this is only a very small beginning. In many localities even basic questions, such as what fertilizing elements the soils need, have not been decided, and secondary problems of fertilization, such as the quantity and form in which the elements should be applied, have not been approached.

Many data, some unpublished, have already been accumulated on the area and chemical composition of the different soils. Such data, however, are not of great value unless accompanied by data of field experiments.

FERTILIZER EXPERIMENTS WITH SUGAR CANE ON THE RED-CLAY SOIL.

INTRODUCTION.

In continuation of investigations previously reported,[1] further fertilizer experiments with sugar cane have been conducted on the red-clay soil. It seems advisable to report the results of these subsequent tests, as there is no opportunity for continuing this work at present.

The experiments previously reported showed that much of the red-clay soil planted to sugar cane did not respond appreciably to fertilizers or the usual soil amendments, while some other areas did respond to fertilizers and to lime. The work detailed below was undertaken to determine the fertilizer requirements of those areas benefited by fertilization. Specifically, the following tests were designed to show what fertilizing element or elements were effective, and to compare the relative effectiveness of different nitrogenous fertilizers, since in the previous tests nitrogen was the only element that appreciably increased the yield.

In this work it was desired to measure whatever increases might be produced by the different fertilizers with considerable accuracy so that the profit or loss could be calculated. To secure this accuracy, each differently treated tenth-acre plat was replicated eight times in each experiment, and in the experiment where half-acre plats were used, the treatments were repeated at least seven times. The field plats were all located in different part of the Anasco Valley on land controlled by the Guanica Central. This company furnished the fertilizers and facilities for conducting the tests.

RESULTS OF FERTILIZER TESTS.

EXPERIMENT AT HACIENDA TRINIDAD.

This experiment, in which the tests were replicated from 7 to 14 times, comprised 73 plats of one-half acre each. It was designed to show the needs of the soil for lime and the fertilizing elements, and to compare the effectiveness of dried blood and ammonium sulphate with sodium nitrate.

The soil was a deep, brownish-black clay, not the distinctive red-clay soil, but more nearly related to this type than any other. The field was low, and during excessive and long continued rains was sometimes flooded. As it was irregularly shaped, it was impossible to arrange the plats in any regular succession, but the replicated plats were all widely separated. The field had been in pasture for 16 months following sugar cane and was considered ordinarily productive land for the district.

---

[1] Porto Rico Sta. Bul. 14 (1914).

Thirty-five hundred pounds of quicklime per acre was applied to certain plats in the first part of February, 1913, and the field was then plowed with a steam plow to a depth of 14 inches. Rayada cane, mixed with Cristalina, was planted in the latter part of March, 1913. Fertilizers were applied in the furrow from June 2 to June 5. The cane was cut the last of March and first of April, 1914.

Phosphoric acid and potash, both applied at the rate of 50 pounds per acre, were derived from double superphosphate and high-grade potassium sulphate. For a comparison of the different forms of nitrogen, sodium nitrate was applied to furnish 50 or 30 pounds of nitrogen per acre, while ammonium sulphate and dried blood were applied in amounts to furnish 30 pounds of nitrogen per acre. As previous tests had shown that the land in this district responded well to nitrogen alone, the plats in this test used for a comparison of the different forms of nitrogen received either sodium nitrate, dried blood, or ammonium sulphate without potash or phosphoric acid.

The cane germinated well and made a good growth for the short growing season, but at no time could any regular differences be seen between the differently treated plats.

In Table 1 are given the maximum, minimum, and average yields of the different plats.

TABLE 1.—*Results of fertilizer experiments at Hacienda Trinidad.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain (+) or loss (−).
		Tons.	*Tons.*	*Tons.*	*Tons.*
Check, no fertilizer	14	34.3	17.3	25.6	....
Lime, 3,500 pounds	8	33.6	17.7	26.3	+0.7
Nitrogen, 50 pounds; phosphoric acid, 50 pounds; potash, 50 pounds	7	33.1	27.5	30.7	+5.1
Nitrogen, 50 pounds; phosphoric acid, 50 pounds; potash, 50 pounds; lime, 3,500 pounds	8	35.1	15.3	26.5	+0.9
Nitrogen, 50 pounds; phosphoric acid, 50 pounds; lime, 3,500 pounds	8	33.6	16.9	25.0	−0.6
Nitrogen (from sodium nitrate), 50 pounds; lime, 3,500 pounds	7	35.5	16.2	24.5	−1.1
Nitrogen (from sodium nitrate), 30 pounds; lime, 3,500 pounds	7	35.9	20.8	27.1	+1.5
Nitrogen (from ammonium sulphate), 30 pounds; lime, 3,500 pounds	7	34.4	16.1	24.2	−1.4
Nitrogen (from dried blood), 30 pounds; lime, 3,500 pounds	7	34.2	17.3	25.8	+0.2

After cutting the cane it became evident that the field varied greatly in productivity, four strips across the field being especially unproductive. It was impossible to correlate the low yield of these strips with any differences in elevation of the land, in drainage, or in appearance of the soil. The high average yield of the complete fertilizer plats without lime is doubtless due to an error in that none of these plats were located in these unproductive strips. Bearing this in mind, it is clear from the table that 3,500 pounds of lime per acre, with or without a complete fertilizer, did not affect the yield nor did any of the incomplete fertilizers nor any of the three forms of nitrogen. A comparison of individual plats in different parts of the field showed that, in all parts of the field, in the more productive as well as in the less productive areas, plats treated with lime and various fertilizers gave no more cane than untreated check plats.

EXPERIMENT AT HACIENDA ALTAGRACIA, FIELD 3.

This experiment, comprising 70 plats of one-tenth acre each, with all tests repeated at least eight times, was designed to determine on this soil the relative needs of sugar cane for nitrogen, phosphoric acid, and potash, singly and in combination.

The soil was typical, stiff, lowland red clay, brownish-red in color, and quite uniform for a considerable depth, the subsoil at 1 foot being only a little lighter in color than the surface soil. The field appeared exceptionally uniform in respect to drainage and character of the soil, and was considered of average productivity. It had been in cane for several years continuously, and previous to that had been left in pasture about every third year.

The land was plowed with a steam plow to a depth of about 2 feet early in April, 1914, and Rayada cane mixed with some Cristalina was planted the latter part of the same month. Fertilizers were applied in the furrow June 25, 1914. Cane was cut April 23 and 24, 1915. The fertilizers were all applied in sufficient quantity to furnish 50 pounds of each element (nitrogen, phosphoric acid, and potash) per acre. Ammonium sulphate was used as the source of nitrogen, double superphosphate as the source of phosphoric acid, and high-grade muriate of potash as the source of potash.

The cane germinated well and grew normally. Three months after the application of the fertilizer all the plats receiving nitrogen alone or in combination with the other elements looked quite a little better than the others.

In Table 2 are given the data on the treatment and yields of the various plats.

TABLE 2.—*Results of fertilizer experiments at Hacienda Altagracia, field 3.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain (+) or loss (−).
		Tons.	*Tons.*	*Tons.*	*Tons.*
Check, no fertilizer	13	24.1	17.0	18.9	....
Nitrogen, 50 pounds	8	27.1	20.2	22.5	+3.6
Phosphoric acid, 50 pounds	8	22.0	15.1	18.8	−0.1
Potash, 50 pounds	8	21.3	17.2	19.4	+0.5
Nitrogen, 50 pounds; phosphoric acid, 50 pounds	8	25.3	18.4	22.3	+3.4
Nitrogen, 50 pounds; potash, 50 pounds	8	26.0	20.0	22.4	+3.5
Potash, 50 pounds; phosphoric acid, 50 pounds	8	24.0	16.0	19.5	+0.6
Nitrogen, 50 pounds; potash, 50 pounds; phosphoric acid, 50 pounds	8	24.5	21.0	22.8	+3.9

The weights of the yield of the individual plats showed that this field was exceptionally uniform in productivity for this class of soil, especially the part covered by the first 50 plats, the part covered by the last two rows of plats being about 20 per cent more productive than the rest of the field. The greater productivity of this portion of the field did not appreciably affect the average results, however, as the plats were well distributed over the field.

The average yields of the differently treated plats show, with a uniformity which indicates the reliability of this test, that nitrogen was the only element that appreciably increased the yield of sugar cane on this soil. The plats which received nitrogen alone or in combination with potash or phosphoric acid, gave an increase over the unfertilized plats of about 3½ tons of cane per acre. Potash and phosphoric acid, alone or in combination, produced no increase of yield exceeding the probable error of the average weights. That nitrogen was the only fertilizing element affecting the yield is further substantiated by the uniformity of the increases produced by the mixtures carrying nitrogen, nitrogen alone giving an increase of 3.6 tons of cane per acre, while the increases produced by nitrogen plus potash, phosphoric acid, or both, did not vary significantly from 3.6 tons.

An increased yield of 3½ tons of cane due to an application of 250 pounds of ammonium sulphate (furnishing 50 pounds of nitrogen) is not sufficient to make the application profitable in all years. The cost of the fertilizer and of its application was about $11. Cane would thus have to net the planter more than $3.10 per ton,[1] or the fertilizer would have to produce a greater increase than 3½ tons per acre to make the application profitable.

---

[1] It is assumed that a ton of cane nets the planter its price at the mill minus the cost of cutting and transportation. In this particular case, cutting and transportation cost about $1.30 per ton. Hence, with cane selling better than $4.50 per ton at the mill, the fertilization would have been profitable.

EXPERIMENT AT HACIENDA ALTAGRACIA, FIELD 19.

An experiment which included 72 plats of one-tenth acre each, with each method of treatment repeated 8 times or more, was a duplicate of the preceding test in Altagracia field 3 in respect to plan and to kind and quantity of fertilizers applied. The field is very similar to the preceding one in respect to soil, but probably slightly inferior in drainage, as it is located nearer the sea and a few feet lower. The soil is very uniform, but some parts of the field vary possibly 2 or 3 feet in elevation and consequently in drainage. It had been continuously in cane for 3 or 4 years, but previous to that was left in pasture about every third year. In regard to productivity, it was considered slightly superior to the preceding field.

The land was plowed with a steam plow to a depth of 2 feet the first of December, 1913. Rayada cane mixed with some Cristalina was planted the last of December and first of January. The cane germinated rather poorly during the dry weather and was partially replanted the last of January. Fertilizers were applied in the furrow February 17, 1914, and the cane was cut January 7 to 13, 1915.

No regular differences between the differently fertilized plats could be distinguished at any time, although there were marked differences between individual plats, apparently due to variations in drainage.

Data on the treatment and yields of the various plats are given in Table 3.

The yields of similarly treated plats varied much more in this test than in the preceding, while the differences due to fertilizers were smaller. It is evident that none of the fertilizing elements used alone or in combination measurably increased the yield. The slight increases attributable to the fertilizers indicate that nitrogen is relatively the most necessary element, although this is uncertain. The results show plainly that the yield of cane on this soil is limited by some factor other than the supply of plant food, and that application of fertilizers this year was made at a loss.

TABLE 3.—*Results of fertilizer experiments at Hacienda Altagracia, field 19.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain.
		Tons.	*Tons.*	*Tons.*	*Tons.*
Check, no fertilizer	15	29.3	12.7	20.8	....
Nitrogen, 50 pounds	8	26.2	20.7	23.2	2.4
Phosphoric acid, 50 pounds	7	25.6	11.4	20.8	0.0
Potash, 50 pounds	8	29.4	19.2	22.0	1.2
Nitrogen, 50 pounds; phosphoric acid, 50 pounds	8	28.6	17.2	22.4	1.6
Nitrogen, 50 pounds; potash, 50 pounds	8	27.5	18.5	22.6	1.8
Potash. 50 pounds; phosphoric acid, 50 pounds	8	29.4	15.7	22.6	1.8
Nitrogen, 50 pounds; potash, 50 pounds; phosphoric acid, 50 pounds	8	30.4	15.4	23.3	2.5

EXPERIMENT AT HACIENDA CIPRIANO, FIELD 19.

This experiment was planned to determine the relative effectiveness of four different fertilizers furnishing nitrogen, namely, ammonium sulphate, sodium nitrate, tankage, and cyanamid. It comprised 75 plats of one-tenth acre each, with all tests repeated at least 8 times.

The soil was the usual red clay, somewhat brighter red in color than that of the fields described in the two preceding experiments, and the elevation of this field, though slight, was greater than that of the two preceding fields. The field had been in pasture for one year, and in previous years had been in cane about two-thirds of the time. The last crop of first ratoons on this land was very poor.

The land was plowed with a steam plow in December, 1913, and planted in January, 1914, with mixed Rayada and Cristalina cane. Germination was poor during the dry weather and some replanting was done later. Fertilizers were applied in the furrow on February 28, 1914. Potash and phosphoric acid were derived, respectively, from high-grade muriate of potash and from double superphosphate.

In June small differences were observed in favor of the plats receiving nitrogen. The cane was cut the last of February and first of March, 1915.

Table 4 shows the fertilizers applied to the various plats and the yields of cane obtained.

TABLE 4.—*Comparison of tests of different nitrogenous fertilizers at Hacienda Cipriano, field 19.*

Fertilizers applied per acre.	Number of plats.	Yield of cane per acre.			
		Maximum.	Minimum.	Average.	Gain.
		Tons.	*Tons.*	*Tons.*	*Tons.*
No fertilizer	15	22.8	12.9	18.8	....
Check, potash, 75 pounds; phosphoric acid, 50 pounds	8	21.4	15.8	19.3	....
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from ammonium sulphate), 20 pounds	7	21.6	19.2	20.3	1.0
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from ammonium sulphate), 35 pounds	8	23.9	16.9	21.7	2.4
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from ammonium sulphate), 60 pounds	8	27.4	22.8	25.0	5.7
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from sodium nitrate), 35 pounds	8	24.5	15.7	21.6	2.3
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from tankage), 35 pounds	8	24.7	18.4	22.3	3.0
Potash, 75 pounds; phosphoric acid, 50 pounds; nitrogen (from cyanamid), 35 pounds	8	26.0	19.5	23.4	4.1

The yields of the 15 check plats show the variation in productivity of the unfertilized field. The yields of the ammonium sulphate plats compared with those of plats receiving only potash and phosphoric acid give data showing the increase in tons of cane due to application of 20, 35, and 60 pounds of nitrogen from ammonium sulphate. These data show what increases would have been produced by all amounts of nitrogen below 60 pounds, and from the figures it can be determined what quantities of ammonium sulphate would have been required to produce the same increases as those actually produced by 35 pounds of nitrogen from sodium nitrate, tankage, or cyanamid. A comparison of these quantities gives the effectiveness of the different forms of nitrogen relative to ammonium sulphate.

As it is evident that 35 pounds of nitrogen from sodium nitrate gave the same increase as 35 pounds of nitrogen from ammonium sulphate, the effectiveness of these two forms of nitrogen was therefore equal. Tankage, however, gave a slightly greater, and cyanamid a markedly greater, increase than the equivalent amount of ammonium sulphate. On the other hand, it appears that 39 pounds of nitrogen from ammonium sulphate would have been required to produce the same yield as that produced by 35 pounds of nitrogen from tankage, while 47 pounds of nitrogen from ammonium sulphate would have been needed to equal the 4.1-ton increase produced by cyanamid. The effectiveness of tankage and cyanamid as compared with ammonium sulphate may be expressed as $\frac{39}{35}$ and $\frac{47}{35}$ respectively. Calling that of ammonium sulphate 100, the effectiveness of sodium nitrate was 100, that of tankage 111, and that of cyanamid 134.[1]

In this test potash and phosphoric acid were applied to all plats to ensure the success of the experiment, hence these results do not show that nitrogen was the only necessary element for cane on this soil. The results do show, however, that nitrogen was one, if not the only, fertilizing element needed. In this test the larger applications of nitrogen were more effective than the smaller, but this would probably not be the case in all years. These data, combined with those of previous experiments, show that 50 pounds of nitrogen per acre is not too much to apply, and that on some of the red-clay soil this application will yield a profit.

DISCUSSION OF RESULTS.

In two of the experiments just described fertilizers were without effect on the yield of plant cane, in a third test they produced a measurable increase, and in a fourth test a marked increase. These results emphasize the point made in the previous report that the application of fertilizers to the red-clay soil is not always productive of results. Including the experiments noted here, those reported in a previous publication[2] of this station, and those reported by the Insular Experiment Station, the results of some 16 field experiments with fertilizers on the red-clay soil at Hormigueros, Mayaguez, Anasco, and Rio Piedras are now available. In only 7 or 8 of these tests did fertilizers produce a measurable or marked increase in plant cane.

---

[1] The advantages of this method for calculating the relative effectiveness of different fertilizers have been noted elsewhere. Gile, P. L., Jour. Amer. Soc. Agron., 6 (1914), No. 1, p. 36.

[2] Porto Rico Sta. Bul. 9 (1910).

From these tests no rule is apparent for predicting just what areas of red-clay soil it will pay to fertilize. The previous history of the land, with regard to the time it has been in cultivation, is evidently not a safe guide. Probably the better-drained areas of brighter red soil are more likely to respond to fertilizers than other areas. Poor drainage with its secondary effects undoubtedly limits the productivity of many areas much more than the supply of plant food.

In the above tests, where the land responded to fertilizers at all, nitrogen appeared the only essential element, as nitrogen alone produced as great an increase as any of the incomplete mixtures containing nitrogen or as the complete fertilizer. That nitrogen is probably the only necessary fertilizing element for sugar cane on the red-clay soil is shown not only by the tests reported here and those given elsewhere[1] but by the test reported by the Insular Experiment Station at Rio Piedras.[2]

As to the best nitrogenous fertilizer for this soil, the test in Hacienda Cipriano seems to show cyanamid as considerably superior to either sodium nitrate, tankage, or ammonium sulphate, the latter three forms being very nearly alike.[3] It should be borne in mind, however, that while the test in Cipriano is about as accurate as can be obtained by field experiment, it is only a single trial with plant cane. Ratoon cane on this soil might have responded better to one of the other nitrogenous fertilizers. Also a slight error in the average weights of cane in this test, due to the soil of one lot of replicated plats averaging slightly better than that of another lot of plats, would have materially affected the results. It is, therefore, felt that while the test with the different forms of nitrogen is fairly reliable, it will not be conclusive until supported by further tests on this soil.

SUMMARY.

The results of four experiments on the effect of fertilizers on sugar cane on the lowland red-clay soil, involving 290 plats and 58 acres of land, show that one field failed to respond to 3,500 pounds of quicklime per acre with and without various commercial fertilizers; on another field all combinations of nitrogen, phosphoric acid, and potash applied at the rate of 50 pounds of each element per acre were ineffective; and on two other fields fertilizers measurably increased the yield.

---

[1] Porto Rico Sta. Bul. 14 (1914).

[2] Rpt. Bd. Comrs. Agr. Porto Rico, 3 (1913–14), p. 56.

[3] On the basis of money values, cyanamid would have been far superior to the other forms, a pound of nitrogen in cyanamid being cheaper than a pound of nitrogen in the other materials.

Where the land responded to fertilizers, nitrogen was the only essential element.

As to the value of the different nitrogenous fertilizers for sugar cane on this soil, a single test with plant cane showed that, calling the effectiveness of ammonium sulphate 100, that of sodium nitrate was 100, that of tankage 111, and that of cyanamid 134.

REPORT OF THE HORTICULTURIST.

By C. F. KINMAN.

COCONUTS.

During the past year an experiment on the fertilization of young coconut palms was undertaken on the plantation of A. J. Harvey, about 4 miles east of the city of San Juan. The area devoted to the experiments lies about a half mile inland and is a level plain a few feet above sea level. The soil is a light but apparently fertile sandy loam which seems well adapted to coconut culture. Plats of 10 trees each have received two applications of fertilizers and one application is to be made every six months until the experiments are concluded. Tests are being made with complete and incomplete mixtures of chemical fertilizers, also with tobacco stems, stable manure, and seaweed in combination with chemical mixtures. It is planned to carry on this work for a number of years as there is a great demand for information regarding the needs of young palms, due to the development of commercial groves on the island wherever the soil conditions are suitable. The results from these tests will be a valuable supplement to those obtained in the work with older bearing palms which has been in progress for a number of years.

The experiments in fertilizing bearing coconut palms undertaken in 1912 are being continued and are giving valuable results. While the application of fertilizers resulted in but little increase in the yield of nuts during the first two years in which the experiments were in progress, marked gains in yields have been recorded during the past year for plats given a complete fertilizer; that is, a mixture containing 6 per cent nitrogen, 8 per cent phosphoric acid, and 12 per cent potash. Where 10 pounds per tree was applied, a gain of over 30 per cent in yield of nuts per tree over the check plat was obtained, and where 20 pounds per tree of the same material was applied, a gain of nearly 60 per cent was noted. Where nitrogen or potash was omitted from the mixture, no increase in yield was recorded, and where phosphate was omitted, there was only a slight increase. The average diameter of nuts harvested from the different plats has varied little since the experiments were first undertaken.

The record of the individual yield of the 350 palms under observation shows that many of them are so unproductive that they are being cared for at an expense and should be removed to provide a larger area for more productive ones or to be replaced by young, thrifty plants. In this field exceptionally productive individuals are no more numerous than exceptionally unproductive ones, and those giving poor yields are as plentiful as those giving good yields. This condition no doubt exists in every part of Porto Rico where coconuts are grown, and every owner should make a thorough canvass to determine the production of his individual palms.

MANGO.

Thirteen varieties of the imported mangoes in the station orchard fruited this year, including Cambodiana, Alphonse, Totafari (Pl. I, fig. 1), Sandersha, Amini, Mulgoba, Bulbulchasm, Davis Favorite, Divine, Sufaida, Paheri, San Pareille, and Martinique. The first three and the last two mentioned were much more prolific than the others, and the first three were the most satisfactory from the standpoint of the commercial planter. The variety Cambodiana has for several seasons seemed the most promising variety for home planting in Porto Rico, as the trees are thrifty, prolific, and regular bearers, and the fruit is first class in texture, flavor, and appearance. As the skin of this fruit is tender, it would probably be less satisfactory for shipping than some other varieties. The fruit of the variety Alphonse, or Bennet, was promising for commercial use this year. The trees bore their first crop when 8 years old. The fruits were of good appearance, flavor, and size, weighing about 14 ounces, the texture of the skins indicating that they would be valuable for shipping (Pl. I, fig. 2). Trees of the variety Amini, which in former years gave promise as a variety for general planting, as they came into bearing early and were prolific in fruit of good size and appearance, gave a small crop this year, and the fruits were too small to be satisfactory for commercial use. Sandersha, a variety suitable for use in making preserves or chutney, as in other years was the most prolific variety. San Pareille and Martinique have proved unsatisfactory for planting. The trees and fruits of these varieties are very similar. The trees are small and very slow-growing, and the fruit, while of good size, is very unattractive in color and unpleasant in taste, with a strong, disagreeable odor when entirely ripe.

In connection with the work with imported varieties, notes have been made on the quality of fruit and seedling growth of different wild types. These uncultivated varieties, found in abundance, are inferior in almost every way to the imported East Indian varieties. The fruits, while pleasant in flavor, are fibrous, undersized, and large seeded, and the seedling trees grow much more slowly than the introduced types, and are therefore less satisfactory for use in grafting and inarching. The slower growth of the wild types is accounted for, partly, at least, by the fact that several plants spring from the same seed and soon exhaust the nourishment, while but one or two plants germinate in a seed of the imported kinds thus far tested. Fruits of imported varieties keep much longer in both cold and common storage than do the wild Porto Rican kinds. Fruits of the former, when allowed to become fully ripe on the tree and then placed in a cold room at 40° to 44° F. were in marketable condition from two to four weeks later, depending upon the variety, while the native kinds given the same treatment had large darkened areas in the skin, rendering them unsalable in from 8 to 12 days.

As the seed covering is very thick and tough in all the common Porto Rican mangoes, tests were made to determine the effect of opening and of removing this covering before planting. Several hundred seed were tested, and it was found that seeds removed from the husk before planting gave far better germinations than those whose husks were opened on one side only, and those opened on one side gave better results than seeds planted just as they were taken from the fruit.

VEGETABLES.

Tests started in 1910 to determine the influence of the Porto Rican conditions on northern varieties of vegetables, when introduced and grown here for a number of consecutive years, were concluded during the past year. Forty plantings (including eight generations) of beans were made with no indications that the later plantings were inferior to the earlier ones. As with all other vegetables under observation, the yield was greatly influenced by the season at which the planting was made. All plantings of beans made in March gave excellent results, while poor yields were realized from June, September, November, December, and January plantings. Okra was grown through eight generations in Porto Rico also, with no indications that the tropical conditions caused any degeneration of the crop. Yields from summer and fall plantings were not sufficiently large to make okra profitable as a commercial garden crop, while winter and early spring plantings produced well. Late summer and fall plantings of tomatoes produced well, while yields from late winter and spring plantings were small. With tomatoes as with other crops, yields in number and size of fruits produced per plant were uniform for all generations grown side by side. Fall plantings always produced abundantly, while the yields from late winter and spring plantings were small.

There is a popular belief in Porto Rico that garden crops brought here from the North degenerate from generation to generation and that seed produced in Porto Rico from these plants can not be depended upon for a satisfactory return. This belief is accounted for partly by the poor harvests from plantings made at unfavorable seasons and partly by the fact that seed lose their viability quickly when exposed to the moist air of Porto Rico, and therefore germinate poorly if stored from one harvest until the next favorable season for planting, which, with most vegetables, is several months, at least on the western end of the island, where the experiments were conducted.

A device employed for preserving the viability of seed during the progress of the experiments was so satisfactory that it is recommended for general use. It consisted of air-tight glass jars in the bottom of which had been placed a few ounces of calcium chlorid. This material was covered with a screen and the jar filled with cloth bags of seed. As the value of the chemical used in this way is in its ability to take up moisture from the air, care must be taken that the jars are kept tightly covered. Metal or glazed earthenware vessels will do as well as glass if kept air-tight.

The results of this work should prove valuable in changing the belief that seed deteriorates in the Tropics and in inducing gardeners of different localities of the island to conduct experiments to determine the best season for planting vegetables and to keep their seed from open air.

A report of these experiments has been prepared for publication as a bulletin of this station.[1]

MISCELLANEOUS INTRODUCTIONS.

Smooth Cayenne pineapple.—Plants sent from the Hawaiian Islands in 1914 arrived at the experiment station in good condition. They have all lived, but at one and a half years from planting are but little larger than when first planted. They were planted simultaneously and in the same field with the Red Spanish and Cabezona varieties, the commercial varieties of Porto Rico. As the latter have grown well and as Smooth Cayenne plants may be found in other parts of the island growing satisfactorily, a local unfavorable condition is probably responsible for the poor growth of this variety.

Algaroba (Prosopis juliflora).—Seed of this tree was imported from the Hawaiian Islands a number of years ago and plants distributed to many parts of the island. In the southern part of the island, where the rainfall is light and the soil contains considerable sand, the trees have grown well and produced good crops of seed

---

[1] Porto Rico Sta. Bul. 20 (1916).

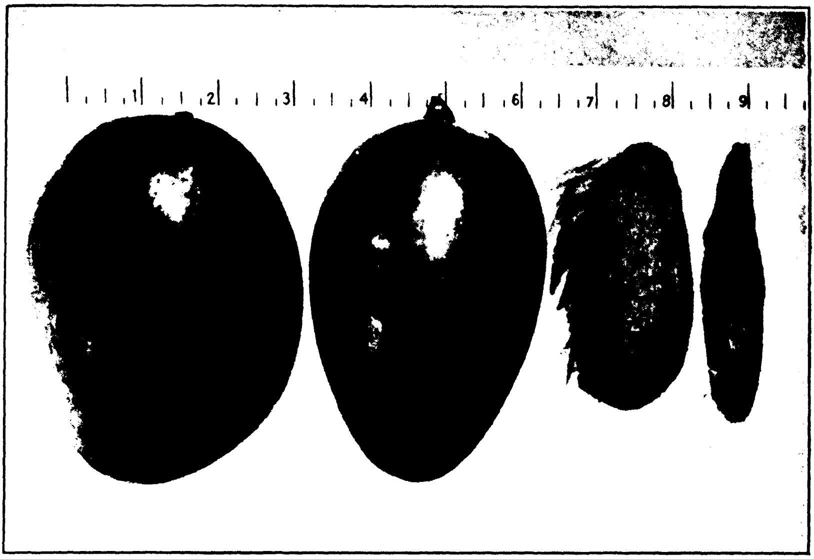

FIG. 1.—TOTAFARI MANGO.

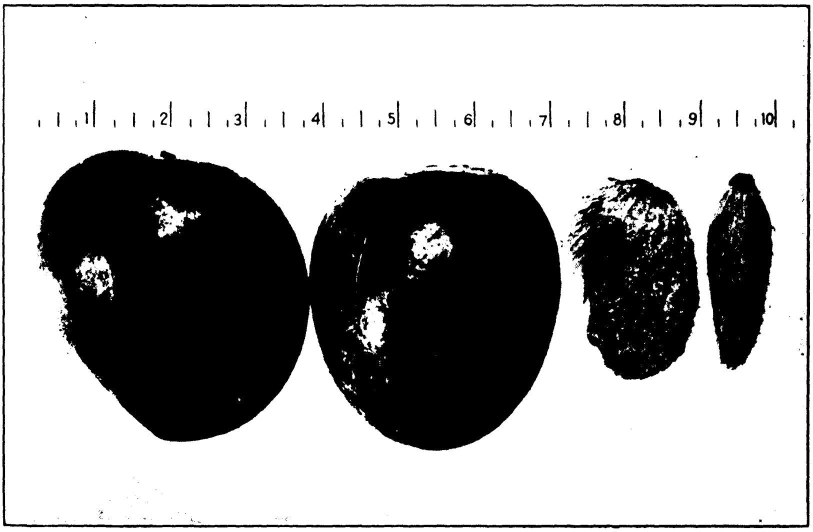

FIG. 2.—ALPHONSE MANGO.

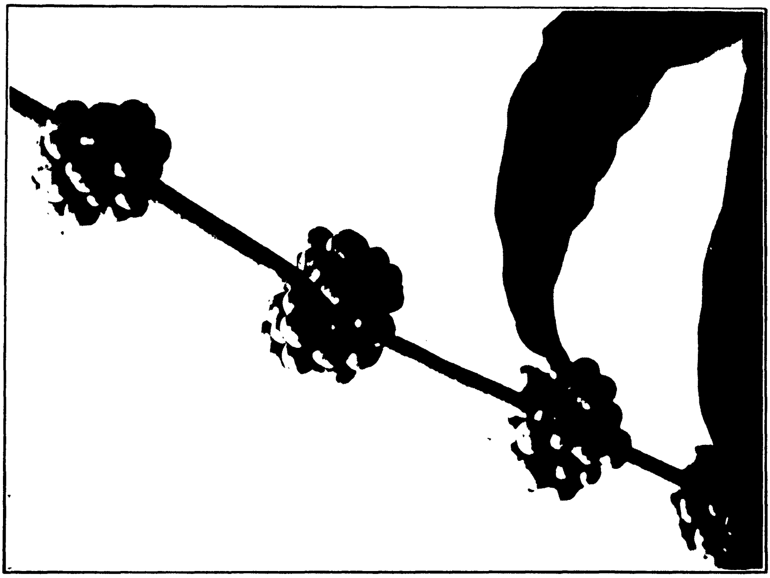

FIG. 2.—ROBUSTA COFFEE IN FRUIT.

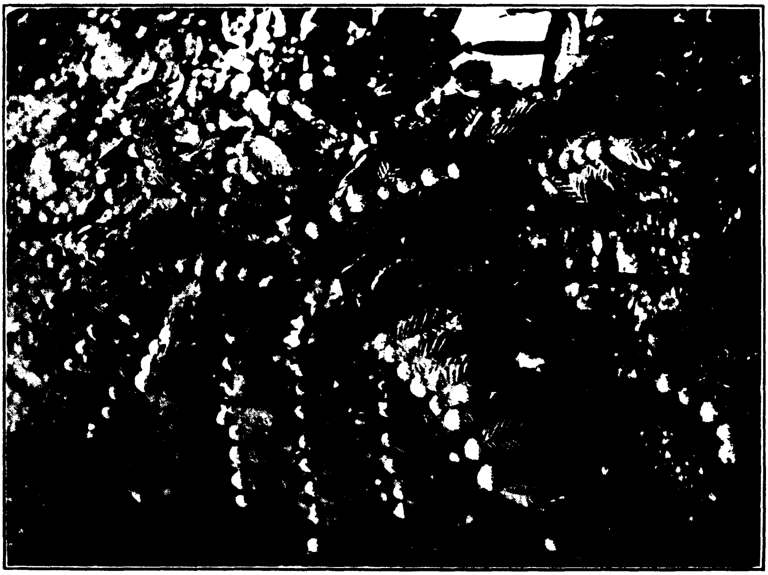

FIG. 1.—ROBUSTA COFFEE IN FLOWER.

in a few years after planting. In the locality of Mayaguez, where the soil is very heavy, the growth has been unsatisfactory. As this is a good shade tree, graceful in appearance, and producing seed pods which make valuable stock feed, it should be tested in all parts of the island.

Canavali incurva (S. P. I. No. 19990).—This canavalia, which is cultivated as a vegetable in a number of Asiatic countries, has been planted at three different seasons during the past year, but its growth has been poor as compared with that of brown and purple seeded types of *C. gladiata* or white-seeded *C. ensiformis* commonly grown here, and it has not been prolific. When the half-grown green pods are prepared as string beans, they have a pleasant flavor and are of good texture, but if allowed to get too large or old, they become very fibrous and an unpleasant flavor develops. Pods only one-fourth grown or less have little flavor.

Botor tetragonoloba (S. P. I. No. 37699).—This bean from the Philippine Islands was sent to Porto Rico in 1914 by the Bureau of Plant Industry, United States Department of Agriculture, and has been very thrifty and prolific. The seed pods when from one-half to two-thirds grown may be eaten as string beans. They are tender and of good flavor, though not so rich as many common garden varieties of beans. The climbing vines have a long growing season, bear large leaves and large showy blossoms, and are suitable for growing around verandas for protection from wind or light.

The results of a winter and a spring planting of a cowpea introduced from India indicate that it is well suited to conditions here. It makes a much heavier plant growth and has a longer growing season than the types usually grown in Porto Rico, and is, therefore, more valuable as a soiling or cover crop. It vines considerably, but not enough to be objectionable in orchards. It is being distributed to planters in different parts of the island for testing.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McCLELLAND.

COFFEE.

Each year shows an increase in the number of coffee varieties in the station plantings. These are frequently sent to the station as selections from valuable varieties grown elsewhere or are received in answer to requests made to meet special needs. This work will doubtless ultimately prove of prime importance, since the present Porto Rican coffee is the result of years of unselected plantings of the same variety, which is forced to grow under widely varying conditions of soil and climate. Some of the introduced coffees already indicate greater adaptability to certain local conditions than the variety now grown. Additions this year include Bourbon, Quillou, several new strains of Robusta (Pl. II, figs. 1 and 2), and seeds from selected individuals. Seeds of promising varieties have been widely distributed.

In continuation of experiments begun some years ago as to the advantage of transplanting coffee from the nursery to the permanent location with the roots incased in a large ball of earth from the nursery, a much more extensive planting was made in August, 1914, more than 300 trees being included in the experiment. In the first 6 months the trees transplanted with roots incased in earth showed more than three times as great an increase in growth as that made by those transplanted with roots bare of earth. For the whole year the growth made by the former more than doubled that made by the latter. A year from transplanting nearly 34 per cent of the former and less than 2 per cent of the latter were producing coffee. These results serve to confirm the conclusions reached in the earlier test.

One fertilizer experiment with coffee trees planted in flat cane land to secure soil uniformity had to be discontinued on account of poor drainage. The other experiments have all been continued. As heretofore, large increases in yield have been obtained as a result of fertilizing.

In pot fertilizer experiments, the need of nitrogen has been clearly demonstrated. Tests were made using red-clay soil to which nitrogen, phosphoric acid, and potash were applied singly, in combinations of two, and the three together. The growth and general appearance of the plants placed them clearly in two groups, one including those plants to which nitrogen had been applied singly or in combination with acid phosphate, potash, or both, and the other of the check plants and those which had received either acid phosphate, potash, or both, but no nitrogen. When the first application of fertilizer was made, the average height of the seedlings of each group was 5.5 inches. At the end of a year the former averaged 40.3 inches in height and the latter 34.2 inches, which also was the exact height of the check. The leaves of the plants which had received nitrogen were dark green, in marked contrast with the yellowish green of those to which nitrogen had not been applied. As the amount of the coffee yield is dependent on the growth made by the plant, the new growth producing the crop, a profitable fertilizer for coffee must be one which produces growth. Nitrogen has been clearly shown to be the element which is most needed for this result on soil similar to that at the station. The pot experiments demonstrated that a need for this element might be indicated by a yellowish-green rather than by a dark-green leaf color.

Measurements of leaf lengths showed that the difference in this particular between the check pots and any other lot was well within the limits of experimental error. However, the nitrogen showed a very marked effect on number of leaves, the check pots having produced an average of 102.3 leaves per plant, those which had received no nitrogen but had received other fertilizer averaged 102.6 leaves per plant, while those which had received nitrogen averaged 117.8 leaves per plant.

As ammonium sulphate was the nitrogen carrier in these tests, it was thought desirable to start a new series comparing sodium nitrate with ammonium sulphate. At the same time another series of pot experiments was started to test under controlled conditions the effect of lime on coffee planted in the red-clay soil.

Some of the trees commonly used for shading coffee harbor injurious insects. Trees not used hitherto in Porto Rico as coffee shade trees are being tested and their development watched in order to find, if possible, some which may profitably supplant in certain localities the trees at present used.

In last year's report a coffee tree was mentioned some limbs of which bore variegated foliage and others only green leaves. Seed from this tree was again planted. Of the seedlings from the variegated limbs 47 had variegated cotyledons and 73 had normally colored cotyledons. From the limbs with green leaves all seedlings, 106, had normal green cotyledons.

CACAO.

In the work with cacao the individual yields of more than 300 trees are being recorded. These records have now been kept a sufficient time to show the prolific tendencies of certain individuals. Pickings are made every 4 to 6 weeks. The maximum yield recorded from a single tree at a single picking has been 54 pods. For the calendar year 1914 about one-fourth of the trees which were set 11 years before produced no crop. The others averaged 17.5 pods, or a gross return of about 22 cents per tree.

From one of the most vigorous and prolific trees a planting of nearly 100 seedlings has been made in order to study the differences to be found in seedlings derived from the same tree.

The color of the bean of *Theobroma cacao* and *T. pentagona* is supposed to indicate the quality. In a single pod from some trees the beans frequently range in color from light to dark. This coloring is still evident in the cotyledons for a considerable time after germination. Separate plantings have been made of seedlings from the same parent tree carrying light and dark cotyledons to see if this cotyledon color bears any relation to the character of the produce of the future tree.

VANILLA.

Efforts are being made to raise some hybrid vanillas, but up to the present no plants have been obtained from seed.

Some very interesting results have been obtained relative to the desirable length for vanilla cuttings, the plants always being propagated by cuttings. Five series were made, each of 16 cuttings, with 4 each of 2, 4, 8, and 12 internodal lengths. At three months only 3 of the 20 shortest cuttings had started growth of vine, while 10 of the next length, 11 of the next, and 16 of the longest had started growth. This new growth measured 9, 30, 52, and 148 inches, respectively, as the total for each length. At 6 months four of the shortest and one each of the next two lengths had failed to put out new growth, while all of the longest had started growth at less than 4 months. The new growth measured at this time 184 inches for the shortest cuttings, 358 inches for the next length, 710 inches for the next, and 1,261 inches for the longest cuttings. This showed unquestionably that with cuttings up to those of 12 internodes every advantage lies with the longest cuttings.

Vanilla is said to be a lime lover. To test this previous to starting cuttings air-slaked lime was supplied to four beds at the rate of 1, 2, 4, and 8 tons per acre. Four months later the bed which had received the heaviest application of lime showed a decidedly retarded growth. At 7 months the growth of vines in the bed which had received lime at the rate of only 1 ton per acre had nearly doubled that of those in the most heavily limed bed and somewhat exceeded the growth in the check, which in turn slightly exceeded that of the two other beds.

In the vanillery nearly all of the 3-year-old vines of *Vanilla planifolia* blossomed, averaging about 10 inflorescences each. A fine crop was developed, which will be cured and marketed to furnish an indication of the value of vanilla grown in Porto Rico.

REPORT OF THE PLANT PATHOLOGIST.

By E. W. Brandes.

EXPERIMENTS IN THE CONTROL OF A BANANA DISEASE.

In another portion of this report an account is given of a banana disease investigated by the former plant pathologist of the station (see p. 36). The soil-sterilization and soil-inoculation experiments described therein have been repeated on a considerably larger scale and by the use of slightly different methods.

In order to have the plants attain full maturity, in a field adjacent to the banana plantation 30 large cylindrical cement tiles, 3 feet in diameter (inside measurement) and 4 feet deep, were sunk in the ground, with the rim projecting 4 inches above the surface, and filled with equal parts of red soil and river sand. The soil in 20 of these cylinders was sterilized with steam generated by a 2-horsepower boiler, the steam passing into the soil by means of a 7-ply steam hose leading to a ramification of perforated pipes driven into the soil to a depth of 30 inches. Steam was passed into these pipes under 60 pounds pressure and allowed to escape into the soil, all parts of which reached a temperature of 110° C. in about half an hour. This temperature was maintained for 1 hour, and the pipes then withdrawn by means of hooks sterilized with carbolineum. The tops of the cylinders were then covered with disks of tar paper soaked in carbolineum and weighted down with stones. Cylinders 1 to 10 were kept sterile by the employment of sanitary precautions, while Nos. 11 to 20 were inoculated with pure cultures of the Fusarium constantly associated with the disease and repeatedly isolated from diseased plants.

It must be admitted here that, owing to the prevalence of the disease on the western end of the island, obtaining absolutely healthy plants for experimental work is difficult, and that the association of the fungus and the disease has not been established satisfactorily by means of Koch's rules of proof, because a large percentage of the control plants develop the disease. Chamaluco suckers were recently received from Naguabo, on the eastern end of the island, which had every appearance of being healthy and from which no Fusarium or other parasite could be isolated. These plants were used in the above experiment, 10 being planted in the 10 sterile cylinders, 10 in the inoculated ones, 10 in the untreated ones, and 10 additional checks in the banana plantation. The first-mentioned 20 plants, besides the disks of tar paper, were protected with wire-net cages, fitting closely to the projecting rim of the cement cylinders, to prevent injury or contamination from insects or small animals.

At the present time, 2 months after the experiment was started, all the plants are making a strong growth, none of them showing any indication of disease. It requires about 18 months for this variety to mature, and external symptoms of the disease do not appear until the plant approaches maturity.

MISCELLANEOUS EXPERIMENTS.

Various spraying experiments have been started to determine the practicability of controlling *Stilbella flavida*, causing a leaf spot of coffee, an undetermined leaf spot of vanilla, and *Pellicularia* sp. on the mangosteen. The latter, which is probably *P. koleroga*, has not been heretofore reported on this host.

A PORTO RICAN DISEASE OF BANANAS.

By G. L. Fawcett.[1]

In Porto Rico the variety of banana known as chamaluco or búlico, which belongs to the plantain group, *Musa paradisiaca*, is very subject to a disease which closely resembles that described as the Panama disease. Its activity does not become apparent in new plantings until the end of the second year, when a few of the shoots that make up each plant have fruited. Then it will be noticed that the petioles of the lower leaves, which are never so dark a green as in some other varieties, have become yellow. Later these leaves die, the dried hanging leaves being one of the most common indications of the disease (Pl. III, fig. 1). If flowering stalks are produced on the diseased plants, these are usually small, the fruits remaining half developed. The most characteristic feature of the disease is noticed on cutting open the bulb-like bases of the diseased shoots, where the diseased tissue has become red or yellowish in color, the still healthy part remaining white. The discoloration will often be found to extend down to one or more decayed roots, which is to be taken as indicating that through these roots the disease found entrance (Pl. III, fig. 2). Sometimes, also, there will be found a continuity of diseased tissue with that of the older shoots, showing that the disease is not always the result of a new infection. The leaves, owing to the injury to the roots and the fibrovascular bundles, are cut off from the source of food material to be obtained from the soil and die in consequence. It is not believed that the various organisms attacking the leaves and apparently causing their destruction are other than secondary.

The chamaluco is really an important plant, its fruit forming a considerable part of the food supply of many of the people. It is preferred to the fruit of others of the plantains, and if it could be cultivated more successfully would be one of the most important economic plants. For this reason the disease has been given much attention, having been studied with the purpose of determining, if possible, the nature of the organism causing the trouble, and also of finding whether, by certain methods of cultivation, the loss could not be lessened.

---

[1] On leave from Feb. 6, 1915; resigned Feb. 6, 1916.

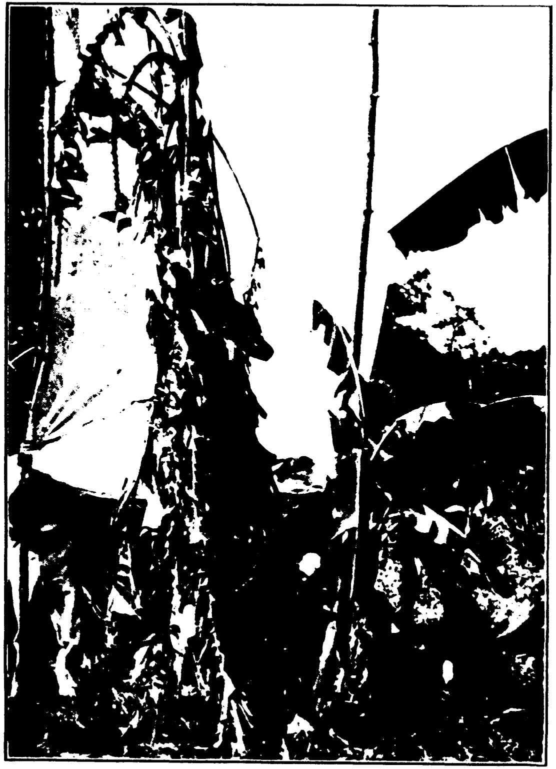

Fig. 1.—Chamaluco Banana in Last Stages of Disease.

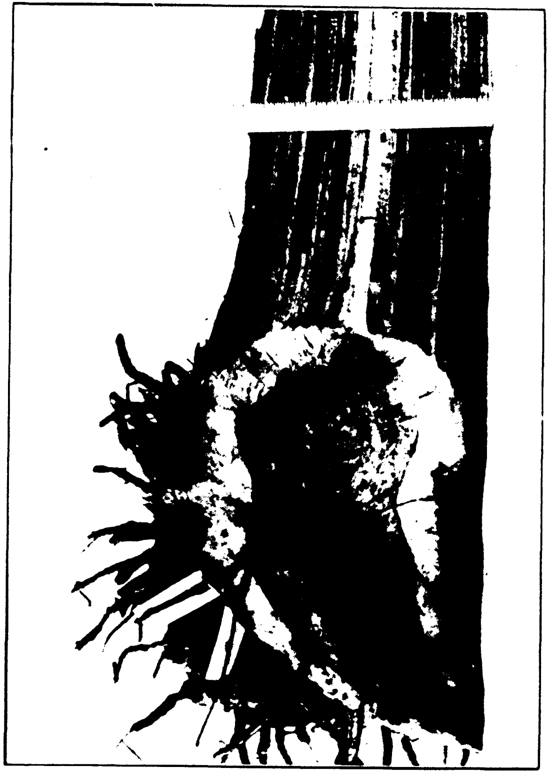

Fig. 2.—Section of Banana Trunk Showing Diseased Areas.

As the use of disease-free "seed" or suckers in planting seemed to offer a practicable means of avoiding, at least temporarily, the bad effects of the disease, a field experiment for testing the use of such seed was begun. For planting, suckers as free as possible from the discoloration were selected, the surface when cut from the mother plant being white, and any injured roots were removed. An equal number of ordinary, slightly diseased suckers were also planted, the two plantings being separated by a ditch. The results of this experiment were as follows:

Comparison of yield from good and poor suckers.

	Poor suckers.	Good suckers.
Number of plants in plats	27	35
Yield (bunches), 1911–1913	27	52
Average yield, 1911–1913	1	1.5
Yield, 1913–1915	9	5
Total yield, 1911–1915	36	57
Average yield for entire period	1.3	1.6

In this experiment the treatment of the two plats was alike as to cultivation, no special effort being made to keep them free from diseased material. The results are not favorable to plant selection, except for the first two years of the experiment. The returns from the selected "seed" for that period were larger than those ordinarily obtained. If it is found by further tests that a decided improvement as to yield results even for the first two years, it would be advisable to use care in selecting the material for planting. That the yield of the last two years was not better is due to the equal abundance of the disease in both plats toward the last. It is clear, however, that disease-free "seed" can give but temporary relief. Although the ground used had not been planted before with bananas, so far as was known, the disease-producing organisms were in the soil as indicated by discolored areas extending down to diseased roots. For this reason it is believed that the principal infection came through the roots rather than from the mother plant, although there is some chance that, in spite of the precautions taken, the seed may have been already infested in some instances. Occasionally, apparently sound suckers with only slightly discolored threads on the cut surface are infected with bacteria, as was found later in selecting seed for inoculation experiments. One of these was used in a soil-inoculation test, and this and another one in direct inoculation into healthy tissues. No proof of parasitism was found, but if such exists and the suckers were already diseased, it is clear that to secure entirely sound plants is difficult.

It is the usual practice in Porto Rico to cut off at some 4 or 5 feet above the ground any shoots that have fruited, leaving the stumps to decay. As it seemed possible that the disease might begin in this material and spread to any younger shoots with which it was in contact, especially as it was found to contain the Fusarium associated with the disease, it was thought that by prompt removal of the shoots that had fruited, the appearance of the disease could be at least retarded. For this purpose two plats of 25 plants each from good, though in some instances slightly infected, suckers were planted, one being left as a check plat, while from the other all the shoots that had fruited and also any others showing signs of the disease were removed. At the end of two years, the yield from the plat receiving the treatment was 25 bunches or 1 bunch per plant, that of the other plat being 35 or 1.4 bunches per plant. The results are thus hardly favorable to the use of sanitary measures.

In the diseased tissues there is always to be found a fungus, a species of Fusarium, the spores of which are 22 to 34 microns long by 4 to 6 microns wide, and the microconidia 5 to 7 microns long by 3 to 4 microns wide. In cultures on rice, the mass of mycelium is at first white, soon becoming pink. When left for several weeks it turns dark blue. In general characteristics, it agrees with Ashby's Fusarium A, described in a paper[1] on the Panama disease. It is also much like that described by Drost[2] for the imperfect stage of *Leptospora musæ*, but the identity of the two is improbable, since no evidences of a perfect stage were ever found, either on the plants themselves or in the cultures, although care was taken to secure the conditions said to favor its development.

Various bacteria occur in the diseased tissues. Inoculations were made with these at various times directly into the bulbs of healthy plants, but no evidence of parasitism was noted. The one chosen for the soil experiment was isolated repeatedly from reddened fibrovascular bundles penetrating well into the healthy tissues, where it often occurred in pure cultures. It forms circular, convex, opalescent colonies rapidly developing on synthetic asparagin glucose agar. A more detailed study of its characteristics was deferred until some evidence as to its parasitism could be secured, cultures being kept for this purpose. In the infection experiments the work was carried on along practically the same lines as those followed by Drost in his work with the Panama disease. That the results were not so convincing as those obtained by him may be taken as evidence that the Porto Rican disease and that of Surinam are somewhat different, the difference being made more probable by the fact that the varieties of banana are different, the Chamaluco being distinct from the Gros Michel, which is the variety subject to this disease in Surinam and Panama, the Gros Michel being unaffected by the disease in Porto Rico. The work was done as carefully as possible, the soil being sterilized for several hours by dry heat, this reaching 155° to 160° during the last two hours. That it was effective was shown by testing some of the soil for the Fusarium and bacteria which had been inoculated with these previous to sterilization. The tests invariably failed to indicate the presence of these or other organisms. The shoots to be planted were disinfected with a 2 per cent copper sulphate solution and washed with distilled water. In selecting the shoots, all those with any diseased roots or other evidence of disease were rejected, the soil was inoculated several weeks before the shoots were planted, the fungus having been accustomed to growth in soil by the addition from time to time of sterilized soil to the plates in which it was cultivated in pure cultures. In the inoculation of the soil with the bacteria, liquid cultures were added to the freshly sterilized soil. In both fungus and bacterial inoculations the soil was moistened with distilled water before adding the organisms. In addition to this, a quantity of a pure culture was placed in contact with a freshly cut part of the bulb at the time of planting. After five months, during which the plants were watered with boiled or distilled water, they were removed and examined.

---

[1] Bul. Dept. Agr. Jamaica, 2 (1913), No. 6, p. 95.

[2] Dept. Landb. Suriname Bul. 26 (1912).

The first series of the infection experiments with the Fusarium consisted of five plants in inoculated soil and two in uninoculated soil as checks, the soil in every case having been sterilized as described above previous to inoculation. The results in this case were negative, as both of the check plants and one of the inoculated ones died soon after the experiment was begun. The death of these checks was probably due to their having been left for a somewhat longer period in the copper sulphate disinfecting solution, the subsequent washing with distilled water possibly not having been sufficient to remove all the copper. The others were typically affected with the disease, the Fusarium being present in the tissues. In a second series with Fusarium, consisting of four inoculated plants and three check plants, one each of the inoculated plants and the checks died soon after starting the experiment. Of the remaining plants, the checks were in excellent condition, while the inoculated ones were badly diseased, the sheaths showing pronounced decay. On examining the bases of the trunks, the checks showed only slightly reddened fibers, whereas the inoculated plants possessed every usual indication of the disease. However, cultures from the diseased tissue showed the Fusarium in the discolored fibers of one of the check plants as well as in those of the inoculated ones.

In the infection experiments with the bacteria in which the organisms already mentioned were used, the procedure was in all respects the same as in the infections with the fungus. Three check plants and five inoculated ones were used. None of the plants died. Both inoculations and checks varied markedly, some plants being healthy in appearance, the others diseased. Unlike the inoculations with Fusarium, no decayed area characteristic of the disease appeared on any of the plants. The reddened fibers were abundant in all. Isolation cultures gave nothing in one of the check plants, and in the others a Fusarium identical with that of the typical form of the disease. The bacteria were isolated from one of the check plants and from all of the inoculated ones, healthy as well as diseased.

Perennial herbaceous plants, like the banana, are especially exposed to infection from the soil, owing to the absence of woody or other protective tissue at places of contact with the soil. It is indeed surprising that the Chamaluco is the only variety suffering from the disease. Several other varieties were examined, specimens being selected at various stages of development. In some of these, bacteria were found well within the center of the trunk. Decayed roots and areas of decay near the surface were common, but neither the typical marks of the disease nor the accompanying Fusarium were discovered.

The decaying leaf sheaths of the older leaves become infected with various bacteria and fungi. That these are saprophytes merely is indicated by their being unable to produce decay in healthy sheaths when inoculated from pure cultures. Similar results were obtained with those isolated from the diseased bulbs and inoculated into leaf sheaths, decay resulting in no instance. When introduced into healthy material from the trunk and kept in a moist chamber, the usual precautions to secure sterile conditions being observed, no decay typical of the disease developed, the nearest approach to such decay being that resulting from the Fusarium. The living tissue is quite resistant to such attacks, although unfortunately not enough so to prevent the disease.

Conclusive results were not obtained from the infection experiments, although they tend to show some degree of pathogenicity for the Fusarium, plants inoculated with this fungus more often becoming diseased than check plants or those inoculated with bacteria. The disease, which is clearly due to parasitic organisms, is slow in action, several months being required to affect the health of the plants. Slight infection is common in apparently healthy young plants.

The condition of the experiments made it impossible to continue each test more than six months, the soil after that time not being sufficient for normal growth of the plants. A much longer period would be necessary to bring out fully the differences between infected and uninfected plants, requiring the sterilization of much larger quantities of soil, a slow procedure at best when carried out thoroughly. Other difficulties include outside infection of soil exposed to the air for the long periods required by slow growing, slow maturing of plants, and obtaining entirely disease-free shoots for planting.

Very healthy-looking ones were found by test cultures to contain the bacteria in the fibrovascular bundles well within the center of the plant. Very definite conclusions have been reached in work similarly conducted in the case of the Panama disease. It would seem, however, that results from work with plants lending themselves so unsatisfactorily to soil inoculation experiments should be given credence only after the work has been repeated and like results obtained by other workers.

To summarize, the results are such as to warrant the selection of healthy, vigorous shoots for planting and the use of fertilizers and cultivation in order that as many fruit-bearing shoots as possible may be produced in each clump before the disease can make enough progress to injure the plants seriously. Soil disinfection to a depth sufficient to be of value is impracticable. Such measures for controlling the disease as those reported used in Surinam and elsewhere with very favorable results are entirely without good effect in Porto Rico. Under present conditions there is little prospect that the Chamaluco can be regarded as more than a temporary crop, as two years from the time of planting it is invariably too much diseased to be of further use. The study of the disease has furnished no proof that it is due to a definite parasite, the Fusarium accompanying the disease answering only in part as its probable cause. It is, however, possible that even a slightly parasitic organism and one of slow growth could destroy the plant by invading the tissues in large numbers. The mass action of an abundant fungus or bacterial growth continued for several months is equivalent in effect to that of stronger parasites acting for a shorter time.

REPORT OF THE ENTOMOLOGIST.

By R. H. VAN ZWALUWENBURG.

The principal work of this department has been with the changa, the cattle tick, and various coffee insects. A bibliographical card index of Porto Rican entomology was obtained through the courtesy of the Insular Experiment Station at Rio Piedras, and has been kept up to date.

As usual, the principal sugar-cane pests were the white grub and the moth borer. The coffee weevil, the leaf-miner, and the hormiguilla were as serious pests of coffee as ever. Among garden insects the changa, the flea-beetle (*Systena basalis*) on beans, beets, and okra, and a tingitid on eggplant were very troublesome. The detailed work on the life history of the changa (*Scapteriscus didatylus*) is progressing well, and various remedial measures are being tested.

The cattle tick (*Margaropus annulatus australis*) is being studied with reference to working out a pasture-rotation method of extermination applicable to Porto Rico. The tick is undoubtedly a most serious drain on the island's prosperity, but there is no reason to believe that this pest can not be exterminated, although the time is perhaps not yet ripe for this work.

INSECTS ATTACKING COFFEE AND COFFEE SHADE.

Experiments were conducted with promising native trees in the hope of finding a tree which the hormiguilla (*Myrmelachista ambigua ramulorum*) can not colonize with guest scales, and which at the same time will provide satisfactory coffee shade. Twelve common native tree species were found to harbor thriving colonies, and no tree suitable for shading coffee was found in which the ants could not be forced to colonize. The pink scale (*Coccus* sp.) has not been found as the guest in ant colonies in coffee, aguacate, or guaraguao (*Guarea* sp.), only the mealy bug (*Pseudococcus* sp.) having been found attended by ants in these three trees. Colonies of the hormiguilla seem to thrive better and consequently to cause more damage when the pink scale is the guest than when the mealy bug alone is harbored.

Observations were made on the coffee leaf weevil (*Lachnopus* sp.). This insect is very destructive to coffee at the higher altitudes; it has not been observed at an elevation lower than 300 meters. The weevil is about one-fourth inch long, varying from "pepper and salt" to a clay color. It produces a characteristic injury through feeding on the edges of young leaves, the blackened ragged edges becoming conspicuous after a few days. The greatest loss, however, is caused by feeding on flowers, young buds, and newly set berries which are to form the crop. The beetle is said to be most troublesome during the months of June, July, and August. Attempts to breed this insect in Mayaguez have been unsuccessful, owing possibly to climatic conditions. A cluster of 54 eggs was laid by an adult in captivity, but all failed to hatch. The eggs are laid in regular rows, being protected by gluing the leaves together. In some districts the weevil is the most serious pest of coffee, doing immense damage near Adjuntas.

GARDEN PESTS.

A very common weevil (*Baris torquatus*) was found breeding in the branches of eggplant, and in some cases it completely killed the plants. The weevil is about 5 millimeters long and strikingly marked with black and white. The adults are very common on berengena cimarrona (*Solanum torvum*), but the writer has not yet observed the young stages in anything but the eggplant. The white, oval egg is deposited within a crescentic slit cut in the stem. The larva is a legless grub about 7.5 millimeters long when full grown. All the developmental stages are passed within the stems of the plant, and as a result control is rather easy. As soon as a branch is found to be infested it should be removed and destroyed. The adults may be collected by hand and killed.

A lace-wing (*Corythaica monacha*) is very common on eggplant. It sucks the plant juice and dries out the leaves, causing them to curl and turn brown. The insects are most numerous on the under-leaf surface and on the topmost leaves of the plant. A 1:10 kerosene emulsion will keep the insect from becoming too troublesome.

WHITE ANTS OR COMEJENES.

There are two very common species of termites in Porto Rico. The one which makes the conspicuous brown runs on tree trunks and builds a papery, dark-brown nest, is *Eutermes morio*, and is the more common of the two. This species often makes its way into houses, doing great damage to furniture and woodwork. A very cheap and efficacious control of this pest is obtained by placing liberal quantities of any powdered arsenical poison in the runways and nest. The insects' habits insure the spread of the poison throughout the colony, and the nest is killed out completely in from one to three days. London purple gives quicker results than Paris green, probably because of the finer division of the particles.

The other species (probably *Leucotermes* sp.) establishes itself in woodwork and furniture, hollowing out irregular galleries with the grain of the wood and often leaving only a very thin partition to conceal the galleries from the outside. Often the first indication of infestation by this species is the presence of fine, granular droppings beneath the wood. Fumigation with hydrocyanic-acid gas is the surest way to control this insect, but stronger dosage and longer exposure than usual are necessary to insure penetration of the narrow galleries.

THE RHINOCEROS BEETLE OF COCONUTS.

Young coconut trees in Porto Rico are often killed by the work of an adult rhinoceros beetle (*Strategus quadrifoveatus*), which enters the nut below the surface of the ground and eats its way upward, attacking the main shoot. Such damage is most common during the rainy season. The adult is the only form causing any damage, since the larvæ feed only in dead wood, such as rotten coconut logs, where the egg is deposited by the adult. The larval period is long, probably requiring over a year for completion. If care is taken to have no logs lying about the grove, no breeding places will be left in the vicinity and the chances of attack by the adults will be lessened. Some coconut growers have trap heaps of decaying logs loosely covered with earth, which are inspected carefully about once in six months, all the larvæ found being destroyed.

MISCELLANEOUS PESTS.

A "round-headed borer" (*Apate francisca*) is very numerous about Mayaguez and during the past year has been repeatedly found boring in young mahogany trees. The young stages have been found only in dead trees, but the work of the adults so weakens the trees that they are easily broken in a heavy wind. Adults at work in a tree can be killed by running a stiff wire into the burrow. This insect also does considerable damage to coffee, citrus, and gandule, or pigeon peas.

Ornamental palms are sometimes disfigured by the work of a lepidopterous larva on the under leaf surface. The small greenish larva works within a loose, frass-covered web, eating the parenchyma.

A noctuid larva (probably *Eriopus floridensis*) is not uncommon on the fronds of ornamental ferns. It is easily overlooked because its color almost exactly resembles that of the plants upon which it rests. In the United States hand picking has been recommended to control this insect.

Coconut trees, especially in the dry region in the southwest corner of the island, are often seriously injured by *Aspidiotus destructor*. Parasitic and predacious enemies do not seem to hold this scale in check. An oil spray is practical in the case of young trees whose leaves can be easily reached. With large trees it will sometimes pay to remove and destroy the leaves most heavily infested.

A very small, dark, long-snouted weevil was found breeding in the flower buds of eggplant. Two or three larvæ are usually found in a single bud. The infested buds dry out, droop, and drop when touched. It is probable that this obscure insect does considerable damage.

Sipha flava, the yellow aphid of sugar cane, was noticed to be very numerous in small areas near Mayaguez. Predacious enemies can usually be depended upon to reduce the number of aphids before serious damage is done, and artificial remedial measures are seldom necessary.

Oleanders are often attacked by a conspicuous orange caterpillar marked with silvery stripes, the larva of *Empyreuma lichus*. The round, yellow eggs are laid on the under side of the leaf in groups, the individual eggs being very regularly spaced one from the other. They have a dull sheen, are slightly iridescent, and under the lens are sculptured with fine reticulate markings. They change to light brown just before hatching. The larvæ average about 26 days from the egg to the pupa, and about 13 days more are spent in the pupal stage. The adult is a striking moth, with crimson wings and a dark-blue body. Hand picking the larvæ will give relief from the pest, which is seldom very numerous on any one plant.

○

Issued February 5, 1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1916.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1918.

Issued February 5, 1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

REPORT OF
THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1916.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*
WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

D. W. MAY, *Agronomist in Charge.*
P. L. GILE, *Chemist.*
C. F. KINMAN, *Horticulturist.*
R. H. VAN ZWALUWENBURG, *Entomologist.*
E. W. BRANDES, *Plant Pathologist.*
H. C. HENRICKSEN, *Assistant in Extension Work.*
W. A. MACE, *Assistant in Extension Work.*
T. B. MCCLELLAND, *Assistant Horticulturist.*
J. O. CARRERO, *Assistant Chemist.*
C. ALEMAR, Jr., *Clerk.*

LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., February 20, 1917.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1916.

Respectfully,

D. W. MAY,
Agronomist in Charge.

DR. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

	Page.
Report of the agronomist in charge	5
Introduction	5
Sugar cane	5
Coffee	6
Tobacco	7
Fruit	8
Minor crops	8
Manufacture of agricultural products	9
Agricultural labor	9
Live stock	10
Lands	10
Report of the chemist and assistant chemist	10
Introduction	10
Bat guanos	11
A plan for testing efficiencies of fertilizers	11
The efficiencies of various phosphates in Porto Rican soils	12
Lime-induced chlorosis	13
Immobility of iron in the plant	14
The assimilation of iron by rice from certain nutrient solutions	15
The absorption of nutrients as affected by the number of roots supplied with the nutrient	15
Report of the horticulturist	17
Pineapples	17
Coconuts	18
Mangoes	19
Miscellaneous introductions	20
Report of the assistant horticulturist	21
Coffee	21
Cacao	22
Vanilla	23
Mahogany	24
Report of the entomologist	25
Introduction	25
The changa	25
Cattle ticks	25
May beetles	26
A cricket attacking seedlings	26
Bees	27
Miscellaneous notes	27
Report of the plant pathologist	28
Inspection trips and identification of plant diseases	28
Herbarium	29
Plant disease survey	29
Banana wilt (Panama disease)	29

ILLUSTRATIONS.

Page.
PLATE I. Fig. 1.—Velvet beans growing to top of jobo tree. Fig. 2.—Seedlings from Cambodiana mango.............................. 16
II. Fig. 1.—Pineapples as affected by (1) complete fertilizer with nitrogen from ammonium sulphate; (2) complete fertilizer with nitrogen from sodium nitrate; (3) no fertilizer. Fig. 2.—Variation in Murta coffee; Arabian type at right, rosette type at left..... 16
III. Cattle tick (*Margaropus annulatus australis*)........................ 24
IV. Fig. 1.—Section of banana stem showing ring of fungus mycelium. Fig. 2.—Method of sterilizing soil for banana plants.............. 28
V. Fig. 1.—Bananas grown in sterilized soil; left inoculated with pure cultures of Fusarium, right uninoculated. Fig. 2.—Experimental plats in banana disease control.................................. 28

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1916.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

INTRODUCTION.

A distinct gain in agricultural production in Porto Rico has been made during the year, with increased profits, as most products have been high in price and the yields have been excellent. This has been true especially of food crops, for which an unprecedented demand has been created by international economic conditions. The high prices have stimulated greater skill, more and better cultivation, and the use of larger quantities of fertilizer. Also more land has been brought under the plow than ever before in the history of the island. This is the factor that promises most for the future, for Porto Rico, though densely populated (about 350 persons to the square mile), has only about 20 per cent of its soil under cultivation, in spite of the fact that it has scarcely any land that is wholly unproductive. The real agricultural problems of the island are to find the crops best suited to the various sections, to induce the inhabitants to grow them, and so to watch the demands of the markets as to secure profits commensurate with yields.

SUGAR CANE.

Sugar continued to be the leading crop, bringing prices during the year which have resulted in large profits. Cane planters for a number of years have studied closely the improved methods of growing cane and have introduced and planted new varieties of seedling canes which are now giving excellent returns.

To induce planters to practice rotation of crops on cane lands is a matter requiring constant attention, as the general custom is to allow such lands to grow up to pasture. The station has been urging the planting of legumes after taking off the last crop. A number of legumes have given good results in rotations with cane, but the velvet bean has proved best. It makes an enormous growth (Pl. I, fig. 1), is well inoculated with nitrogen-storing bacteria, and yields a large quantity of forage, which is very necessary for the herds of work cattle used in cane production. Moreover, the velvet bean is easily planted, and it is scarcely more expensive to grow this crop than to allow the land to lie fallow.

Another good practice advocated by the station is that of planting beans in the young cane. One of the largest Porto Rican importations is the red bean, which, with rice, is the principal article of diet of the people. Not only is the growing of this crop profitable in itself, but the practice greatly improves the land by storing nitrogen, the fertilizing element most needed by Porto Rican soils. Since the laborer needs the beans for food, and the planter needs nitrogen in his soil, the mutual advantage of permitting the laborers to plant beans wherever possible is evident. A crop of beans may be grown in the young cane at a profit, but the resulting improvement of the soil will repay the owner, though he give the cultivator the entire crop.

COFFEE.

The coffee industry has lagged throughout the year. Prices have been low, and while other agricultural products, many of which the coffee grower has to buy, have increased in price, his money crop has brought poor returns, and the difficulties of marketing it have been great. Europe was the established market for Port Rican coffee, but the war has not only curtailed shipments to many countries, but has wholly stopped intercourse with others. Increasing quantities, however, have been sent to Cuba, especially of the better grades.

Attempts to sell Port Rican coffee in the States have been continued, but with slight success. It is very hard to reach the consumer in the States with a coffee of standard excellence. The consumer takes what his grocer gives him, usually a blend in case of the better grades, which is generally made up of a large quantity of cheap coffee with the smallest possible quantity of an aromatic sort to give flavor to the whole. Such a mixture will average less in cost than the usual market price of Porto Rican coffee in Europe. The merchant has no sentimental interest in marketing coffee, and it is difficult to reach the consumer without his assistance. Even if a demand for a particular variety is created, the buyer frequently can not get it when he wants it, as the total Porto Rican coffee crop is sufficient to supply only a small fraction of the quantity of coffee consumed by the United States.

Again, the most valuable quality of coffee is its flavor, and a taste for a certain flavor is hard to change. People coming to Porto Rico to live usually do not like the flavor of the coffee; but after drinking it for a while they develop a taste for it, and upon going to a district where another coffee is used they do not care for the new sort.

If people in the States could be induced to return to the old way of buying their coffee green and roasting it as needed, then an excellent coffee like that of Porto Rico would find a market and hold it, and the consumer would reduce materially the high cost of living as well as obtain a better product, as fresh-roasted coffee is superior to the average blend found on the market. Moreover, green coffee improves with age instead of deteriorating, as the general run of products do. The housewife, however, on account of the scarcity of help, is loath to return to methods requiring extra labor when the grocer or coffee roaster is ready to take work off her hands.

A movement promising better success for the coffee growers is the formation of an association which will arrange to have Porto Rican coffee roasted and packed under its own name and brand and to sell its product through a chain of stores or by agreement with grocers who will give it a thorough trial, the growers carefully safeguarding the quality and freshness at all times.

The condition of the coffee planter is a really serious one. Many of the plantations have grown coffee for half a century, and now the trees are too old and the soil too worn to be productive. The remedy for this condition can not be applied quickly, as it requires time and study. Unproductive lands no longer planted to coffee are denuded of their timber and become washed and sterile. It is impossible to get such lands back into coffee without a long series of rotations.

The station has 200 acres of denuded land which reverted to the government. It is bare except for sparse wire grasses and is wind swept and gullied. In getting this area back into cultivation some years without profit must be faced, as even quick-maturing legumes like beans and peas have not returned the seed, while kafir corn, milo maize, rice, and grasses have failed entirely. Peanuts and velvet beans made returns and some unusual plants like roselle yielded crops. Velvet beans are most promising for starting high lands on the return to fertility, and these, with other legumes and live stock, are the surest means of redeeming such areas.

Diversification is the only hope of most coffee growers. On most of the lands not accessible to good roads, crops for export should be such that they could be shipped easily; that is, they should be neither bulky nor perishable. Such imports as beans, which form a large part of the food of the people, could be grown on the coffee plantations. It is hard, however, for the coffee grower who has been a bonanza farmer to take up a small crop, even if it is profitable. Although red beans retail as high as 18 cents a pound and are brought from countries as far away as Manchuria, their production appeals to the coffee grower as a small business.

TOBACCO.

The growing of tobacco in Porto Rico has increased, and the quality of the product has been improved greatly. From the areas where tobacco has been grown for many years, the crop has spread to suitable fields in nearly all sections of the island. New methods of fertilizing, curing, and fermenting have built up a reputation for Porto Rican cigars, and they may now be found in all the principal cities of the United States. By judicious advertising and a continuous improvement in quality the sale of Porto Rican tobacco has been increased enormously.

Through lack of organization the tobacco growers of Porto Rico miss many opportunities for studying improved methods and for securing better prices. On the other hand, the factory employees are the best organized laborers in Porto Rico and receive the highest wages.

FRUIT.

The problem now facing fruit growers is not increase in production but improvement in quality of product. Prices throughout the year have been low. Some excellent fruit has been shipped which has brought good prices, but the larger part has been poorly packed or defective in appearance or quality. Much fruit is shipped that should be made into by-products or be discarded. Shipping such fruit results in a loss, not only to the individual grower but to the industry as well. The quality of fruit must be maintained if the industry is to succeed.

Improvement in the fruit industry will come only through organization and closer cooperation, especially in packing and marketing. A distinct gain is made along the latter line in the establishment of community packing houses and in concerted attempts at standardization. Two organizations among the fruit growers that are already proving beneficial are working on community packing houses, the standardization of marks, marketing, and the purchase of supplies. Their organization and work should be strengthened, as it is the most promising move in the industry at this time.

Hastening the coloring of citrus fruit by sweating has been practiced lately. This has been done in order to place the fruit on an earlier market and has resulted in the sale of a great deal of immature fruit. This very short-sighted policy, which has already injured the fruit industry of Porto Rico, should be most earnestly condemned. If the growers themselves by concerted action can not stop the practice, the law should be invoked. Fortunately the pure-food officials, both national and local, have taken up the matter. Fruit growers should cooperate with them to suppress the practice of marketing immature fruit, which, instead of increasing demand and consumption, threatens the very life of the fruit industry.

MINOR CROPS.

Of the smaller crops, the production of those consumed locally has made the greatest increase. They should, however, be more greatly extended. The fact that 80 per cent of the land of Porto Rico is idle, while $5,598,799 worth of rice, the principal food crop, is imported, shows the possibilities of this crop on the island. Beans and peas costing $819,703 were imported during the year, yet these can be grown easily in nearly all sections of the island. The major crops give such an impression of easy profits as to overshadow the minor ones, some of which would yield larger returns. Porto Rico is striving to increase its export trade, yet it could with greater profit produce the foodstuffs now imported, thus obviating the danger of food shortage.

MANUFACTURE OF AGRICULTURAL PRODUCTS.

Porto Rico is especially adapted to carrying on manufactures of certain agricultural products. A large supply of labor is available which can maintain itself at little expense under the favorable living conditions on the island. Tobacco manufactures have reached the greatest development; others are growing and still others are being established. The household industries are best adapted to the habits of the people. The weaving of hats, for example, has grown enormously. Hats valued at more than half a million dollars were exported from Mayaguez during the year.

AGRICULTURAL LABOR.

Agricultural labor, in spite of a greater demand in other countries, continues to be comparatively plentiful in Porto Rico. The higher cost of living has not been met by corresponding increase in wages, and there has been a great deal of unrest, resulting in strikes in certain industries. Most of the laborers are unskilled and unorganized. They are fairly efficient in doing handwork with tools which they have used through several generations, but they are slow in learning to use machinery and in applying new methods. Aside from the desire to see their children's condition improved, they show little ambition and are especially averse to working for themselves, preferring rather to offer their labor in an often overcrowded market and producing about their homes little or nothing which would reduce the cost of living or tide them over periods of idleness. Emigration is slight and the birth rate is very high, the resultant excess population producing on some plantations, especially in the interior, deplorable economic conditions. It is impossible for the plantation owner to give employment to all the people occupying his land, yet the plantation must support them without return. They thus become parasitic on the plantations or wander down into the already overcrowded towns.

LIVE STOCK.

Owing to the greatly extended planting of sugar cane, the demand for work cattle has increased, and their value has advanced greatly. Milk has been scarce during the year, retailing at as high as 18 cents a quart, and suffering has resulted.

To grow more live stock, more forage must be grown. The pasture lands of the hills grow scanty grasses, some of which are unpalatable. The station has introduced and is distributing Sudan grass, kafir corn, and other forage plants giving profitable returns outside of Porto Rico. The velvet bean is proving one of the best forage plants introduced, not only for live-stock production but for soil improvement.

As cattle have been bred in Porto Rico mainly for work purposes, the native animals have size and vigor, but their milking qualities should be improved. Owing to the presence of tick fever on the island, considerable risk is involved in importing high-priced, well-bred animals. However, on every plantation where cattle are raised in any number a pure-bred sire could be kept with little risk if carefully handled. The station has tried this plan and, besides, has not only assisted breeders in importing cattle but, to improve the cattle in different sections, has sold at reasonable prices animals bred in the station herd.

Pigs usually are raised singly and subsist mainly upon offal. That they can be raised at a low cost has been demonstrated at the station. Before the industry can be greatly extended, the number of grain and root crops suitable for pig feeds should be increased.

LANDS.

Although the prices of products have fluctuated somewhat, land values have increased steadily since the American occupation. In spite of this it has been and is difficult for the landowner to secure money on his lands at a reasonable rate. In some cases where he obligates himself to sell his crop to the lender, he can get money at a fair rate, yet this practice is not to be commended. The borrower usually pays 12 per cent, a rate which, while legal on the island, is unreasonable, in view of the very safe security offered, and often disastrous for an agricultural enterprise.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and J. O. Carrero.

INTRODUCTION.

During the year 1916 the investigation of guanos and some studies incident to the investigation of lime-induced chlorosis were completed and the results prepared for publication. New work was undertaken on the efficiencies of different phosphates in Porto Rican soils. A certain portion of the work accomplished on these subjects was published in various journals, as the detailed results were somewhat technical. A summary of these articles and of progress in the different investigations is given below.

BAT GUANOS.

Deposits of bat guano are especially common in the Tropics and in subtropical regions, although they are generally of small size. As the fertilizing values of bat guanos and the similar leached bird guanos have never been studied thoroughly, the investigation of Porto Rican bat guanos is of some general interest.

This work, was carried out in considerable detail. Vegetation experiments, which comprised results from over 2,300 pots, were conducted to determine the immediate availability of the nitrogen in 39 samples of guano and the immediate efficiency of the phosphoric acid in 94 samples. Tests also were conducted with many samples to determine the extent to which the efficiency of the phosphoric acid was affected by the kind of soil, the crop, liming, remaining in the soil, the stage of growth of the crop, and the quantity of guano used.

A monetary value was assigned the different guanos based on prices of the fertilizing elements prevailing before the European war. The values of the different guanos examined varied between nothing and $47.60 per dry ton, the average for 247 samples being $7.14. Probably the total quantity of bat guano existing in Porto Rico is worth less than $300,000. It is evident, therefore, that bat guanos will form hardly an appreciable part of the fertilizers consumed on the island. They always, however, should constitute one of the minor sources of fertilizer supply, as even after all the old material has been extracted a small but continuous supply of fresh material worth several thousand dollars annually will be available.

The practice of frequently extracting the fresh guano should be followed, as in all caves except very dry ones the fresh material is more valuable than partially decomposed and leached guano, being worth about $30 per dry ton. Moreover, the fresh material is of fairly constant composition and availability and so may be used without frequent analyses.

A PLAN FOR TESTING EFFICIENCIES OF FERTILIZERS.

In connection with the work on bat guanos some data were accumulated regarding the proper plan to be used in testing the efficiencies of fertilizers. A discussion of this was presented in a recent paper by the writers[1] and is summarized here.

---

[1] Jour. Amer. Soc. Agron., 8 (1916), No. 4, pp. 247-255.

Tests of the relative efficiencies of fertilizers, as usually planned, involve the application of only one or two quantities of the standard fertilizer. Relative efficiencies are then calculated on the basis of the relative increases produced by the different fertilizers. It was pointed out that this method is based on the assumption that equal and successive increments of the fertilizer in minimum will produce equal increments in yield and that this assumption is often false. Attention was called to some conditions affecting the manner in which the crop yield increases with increase in fertilizer.

It was proposed that tests of the efficiencies of different fertilizers furnishing the same element should include applications of three to five different quantities of the standard fertilizer, and that from the data of tests so planned the efficiencies should be calculated on the basis of the relative quantities of the different fertilizers required to produce the same increased yields. This method was used in the work with bat guanos.

The advantage claimed for the proposed method is that, being based on no assumption concerning the law of minimum, an accurate comparison is possible irrespective of how the yield increases with increasing amounts of the fertilizer in minimum. The form of the curve, plotted from the increased yields produced by increasing amounts of the standard fertilizers, shows when a calculation of relative efficiencies is allowable and gives some idea of the accuracy of the comparison. As the proposed method involves the idea of always comparing yields of approximately equal magnitudes, an analysis of the crop and a determination of dry matter are not so important as in the old method. This principle of the proposed method is of particular value for vegetation tests in pots where large and small yields are subject to somewhat different conditions in respect to ratio between soil and root volume and total amount of mineral matter supplied in the water.

THE EFFICIENCIES OF VARIOUS PHOSPHATES IN PORTO RICAN SOILS.

During the past year work was begun on the use of different phosphates on Porto Rican soils. This study is expected to occupy most of the time and facilities available during the present year. By means of vegetation experiments in pots it is planned to determine the relative efficiencies of acid phosphate, basic slag, bone meal, finely ground rock phosphate, and double superphosphate in as many of the different Porto Rican soils as possible; the effect of liming on the efficiency of these phosphates in acid soils which normally would receive lime; and, to some extent, the rate at which the different phosphates become unavailable in various soils. As many soils as possible will be tested in this way. Work was started with soils in the citrus district where fertilizers are used to the greatest extent and where phosphatic fertilizers are necessary.

The results afforded by vegetation experiments in pots can not be taken as applying in their entirety to field conditions, and such is not the intention in these experiments. For instance, this work will not show the degree to which the soils will respond to phosphatic fertilization in the field with different crops. This can be determined only by field experiments with the different crops, and in some cases this has been done. This work should show, however, the best form in which to apply the phosphoric acid in case phosphatic fertilizers are to be used. Also it should furnish information concerning the length of time the different phosphates remain available in the soils. This information is particularly valuable in fertilizing long-time or permanent crops, like pineapples and citrus fruits.

LIME-INDUCED CHLOROSIS.

During the last few years more or less work has been done on lime-induced chlorosis as opportunity offered. The results of numerous experiments now seem to show fairly conclusively that the chlorosis of certain plants in highly calcareous soils is due solely to a lack of iron in the plant. The experiments indicate that calcium carbonate causes this lack of iron in the plant by depressing the availability of iron in the soil without having any other secondary effect on the plant.

The study of lime-induced chlorosis thus becomes largely a study of the assimilation of iron by the plant and the factors affecting the availability of iron in the soil. Recently the work was prosecuted along these lines. A test of the availability of certain organic iron compounds in a calcareous soil is being conducted. A series of experiments with rice grown in nutrient solutions was carried out to determine the effect of the reaction of the solution on the growth of rice and assimilation of iron. The results are summarized below. Evidence on the movement of iron in the plant was secured. A report of this is given below.

In connection with some of the direct experiments on the nature of chlorosis it was necessary to ascertain how the absorption of a mineral nutrient was affected by the number of roots supplied with the nutrient. As this work was somewhat technical and probably will be published in a journal, a brief description of the results is given below.

It is hoped that during 1917 the direct experiments on chlorosis and certain parts of the work reported in special articles can be prepared for publication as a bulletin.

IMMOBILITY OF IRON IN THE PLANT.

Evidence concerning the immobility of iron in the plant after transportation to the leaves was presented in a recent publication of the department.[1]

The observations on the immobility of iron dealt chiefly with its nontransference from leaf to leaf when the plant was insufficiently supplied with iron. When the plant is insufficiently supplied with nitrogen, phosphoric acid, or potash, there is a transference of these elements from old leaves to younger ones where growth is more active. The distinction between iron and the mobile elements was made evident by the growth of rice in media lacking in these elements. Rice grown for a time with iron and then without iron commenced to show chlorosis and die in the upper leaves, the lower ones remaining green. When the plants were grown in media lacking nitrogen, phosphoric acid, or potash, the lower leaves died first, these mobile elements being translocated to the new leaves.

This evidence concerning the immobility of iron was supported by observations on plants affected by lime-induced chlorosis, by the local effect produced by brushing portions of chlorotic leaves with iron salts, and by ash analyses of old and young leaves.

If iron is really immobile after it has once been transported to the leaves, as the evidence seems to show, certain peculiarities in the behavior of plants affected with lime-induced chlorosis are explained easily. For instance, it is clear that a plant as a whole or certain parts of a plant might lack iron, while other parts, as the lower leaves, might contain a sufficiency. Thus, in analyzing chlorotic plants to demonstrate a lack of iron it probably would be well to analyze more than one part, as both upper and lower leaves. Occasional anomalous results that were secured in comparing the iron contents of green and chlorotic plants doubtless were due to including parts of chlorotic plants that contained sufficient iron.

The immobility of iron in the plant also explains the temporary nature of the effect produced by spraying chlorotic plants with iron salts. Repeated observation showed that whereas leaves of plants affected with lime-induced chlorosis became perfectly green on spraying with iron salts, new leaves, that appeared directly or soon after the treatment, were chlorotic. This could hardly have been due to the fact that only enough iron penetrated the treated leaves to suffice for their needs, but doubtless was due to the immobility of the iron after entering these leaves. Also, it probably is due to the same cause that the method of applying iron salts to the cut surfaces of chlorotic vines has proved more successful in France than spraying the leaves.

---

[1] U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 2, pp. 83-87.

THE ASSIMILATION OF IRON BY RICE FROM CERTAIN NUTRIENT SOLUTIONS.

As calcareous soils are slightly alkaline in reaction, it was considered important to determine whether rice, which becomes chlorotic on such soils, is sensitive to the reaction of the medium in which it is grown and whether the reaction of the medium affects the assimilation of iron. The results of this investigation have been published already.[1]

The growth of rice was measured in acid, neutral, and alkaline nutrient solutions containing 0.002 and 0.008 gram iron per liter from ferrous sulphate, ferric chlorid, dialyzed iron, ferric citrate, and ferric tartrate, and the amount of iron assimilated was determined by analyses of the plants. When certain quantities and kinds of iron were used, the growth of rice and the amount of chlorosis varied considerably in the nutrient solutions with different reactions; but with the other quantities and kinds of iron the reaction of the solution had little effect on the plants. In most cases growth and quantity of iron assimilated were greater in acid solutions and least in solutions made alkaline by carbonate of lime. With ferric tartrate as a source of iron, however, growths made in the three solutions were practically equal.

The data show quite clearly that rice is sensitive to the reaction of the nutrient solution only as the reaction affects the availability of the iron. This confirms the results of experiments conducted with rice grown in calcareous soils in regard to the appearance of chlorosis.

Incidentally this investigation brought out other facts of importance in regard to the assimilation of iron by rice. Further evidence was added to that obtained in previous experiments showing that very finely divided or colloidal iron is not available to rice.[2] Evidence also was obtained indicating that rice is able to assimilate sufficient iron from exceedingly dilute solutions, it appearing from calculations given that sufficient iron doubtless can be secured from solutions where the concentration of truly soluble iron is 1 part or less in 10,000,000.

This work, while indicating that certain factors probably influence the availability of iron in soils, also points out the great difficulties that would attend an attempt to determine directly the amount of available iron in different soils.

THE ABSORPTION OF NUTRIENTS AS AFFECTED BY THE NUMBER OF ROOTS SUPPLIED WITH THE NUTRIENT.

In studying the chlorosis of rice, it became necessary to know whether a plant could absorb sufficient iron with part of its roots, provided all of its roots were supplied with all other essential nutrients. A general study was made of this question and the results submitted for publication.[1]

---

[1] U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 12, pp. 503–528.

[2] U. S. Dept. Agr.. Jour. Agr. Research, 3 (1914), No. 3, pp. 205–210.

The experiments were conducted with corn and rice in water cultures, the plants being grown with part of their roots in a complete nutrient solution and part in a nutrient solution lacking one element only. In this way the absorption of nitrogen, phosphorus, potassium, and iron was studied. In some tests one-half the roots of the plants were maintained in a solution lacking one of these elements, and in other tests three-fourths or two-thirds of the roots.

The results obtained were surprisingly uniform in some respects. It appeared that when a portion of the roots was not supplied with one element the plant could not absorb a maximum amount of this element with the rest of its roots. The fewer the roots that were supplied, the less nearly the plant attained a maximum absorption of the element. A curve was plotted showing what portion of the maximum absorption could be expected with any fraction of the roots supplied with the element. This curve agreed with Mitscherlich's formulation of the law of minimum.

Under the conditions of these tests, plants with half their roots absorbed 0.76 as much nitrogen or phosphorus as plants with all their roots in the complete solution. The similar figure for potassium or iron was 0.66. Increasing the concentration of the element in question in the complete solution did not alter appreciably these figures. These results were obtained under conditions where the total amount of the element afforded part of the roots was equal to or in excess of the amount needed for maximum absorption.

Although the plants never attained a maximum absorption of an element with a portion of the roots, the amount of the element absorbed per gram of roots increased markedly as the number of roots supplied with the element decreased. With only one-fourth of the roots supplied with nitrogen in the complete solution the amount of nitrogen absorbed per gram of roots was a little more than double that absorbed per gram of roots by plants with all their roots in the complete solution.

As the results obtained are due to the way the plant functions in absorbing mineral elements, they are, to a certain extent, applicable to soil conditions and have a direct practical bearing. It is obviously important to apply fertilizers so that as far as possible all the plant's roots will be supplied with the fertilizing element or elements. The lateral diffusion of fertilizing salts being small, this can best be brought about by distributing the fertilizer over the whole area occupied by the roots.

When fertilizers are applied to only part of a plant's roots, various conditions will determine how completely the fertilizer is absorbed.

---

[1] U. S. Dept. Agr., Jour. Agr. Research, 9 (1917), No. 3, pp. 73-95.

PLATE I.

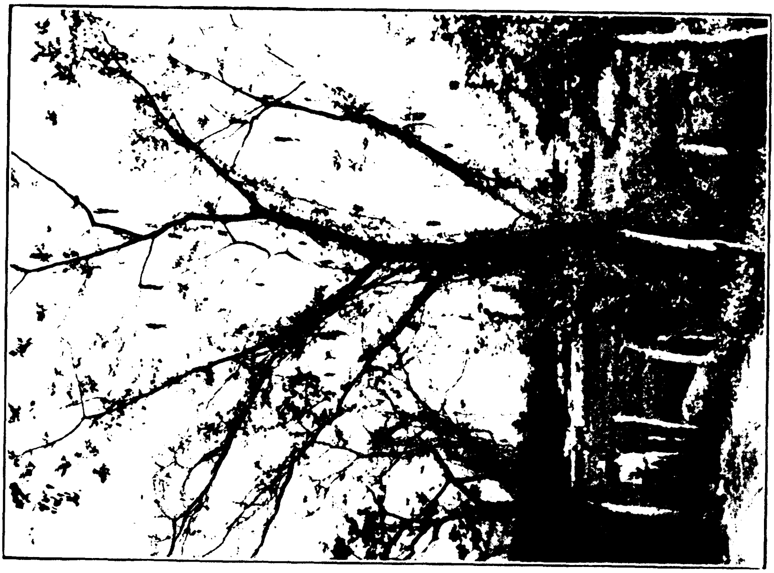

FIG. 1.—VELVET BEANS GROWING TO TOP OF JOBO TREE.

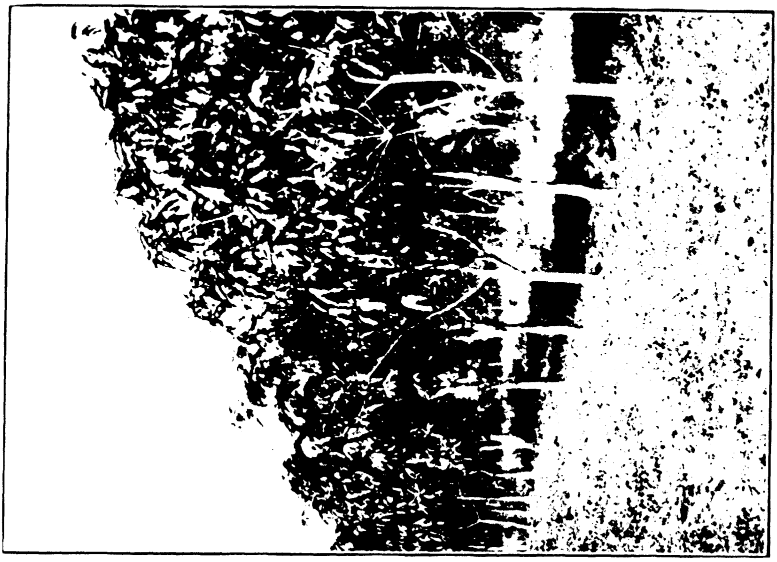

FIG. 2.—SEEDLINGS FROM CAMBODIANA MANGO.

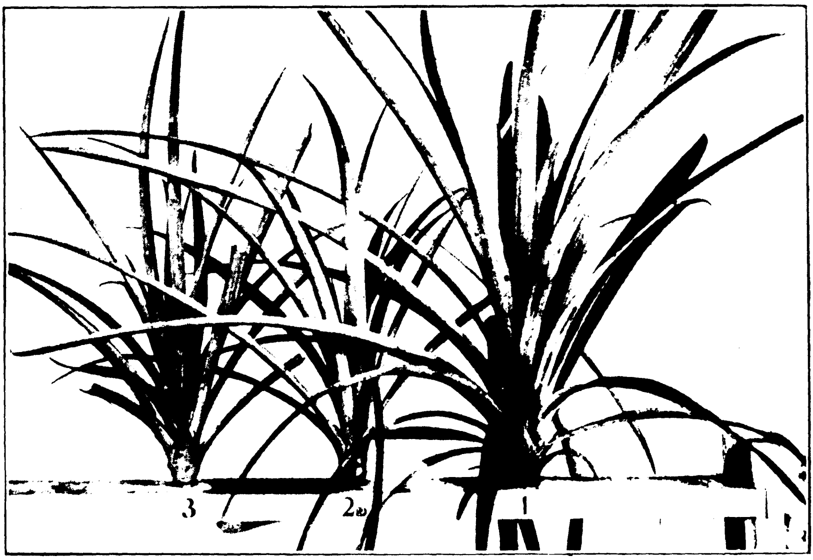

FIG. 1.—PINEAPPLES AS AFFECTED BY (1) COMPLETE FERTILIZER WITH NITROGEN FROM AMMONIUM SULPHATE; (2) COMPLETE FERTILIZER WITH NITROGEN FROM SODIUM NITRATE; (3) NO FERTILIZER.

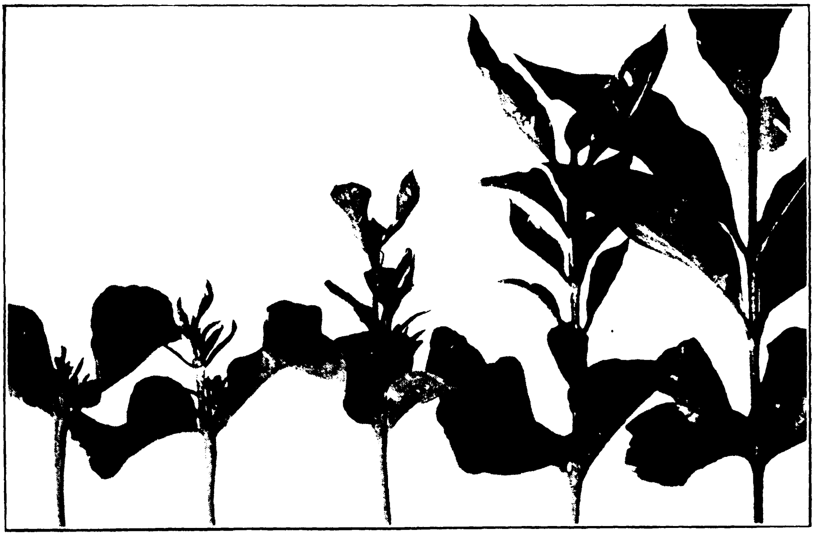

FIG. 2.—VARIATION IN MURTA COFFEE; ARABIAN TYPE AT RIGHT, ROSETTE TYPE AT LEFT.

The exact figures obtained in this work evidently will not apply to field conditions. For instance, there is a tendency for root growth to become more luxuriant in those zones where the fertilizer is located. This would tend to make the absorption of poorly distributed fertilizers more complete than would appear from the figures obtained in this work. It also should be borne in mind that only under very exceptional field conditions are plants entirely dependent on a fertilizer for their supply of a nutrient. We may say that most of the roots are supplied to a greater or less extent with all the nutrients. This would tend to make the absorption of fertilizer applied to a few roots less than the figures obtained in this investigation.

The quantity of fertilizer applied to a few roots would also affect the completeness of absorption. If the quantity were nearly or quite equal to the plant's requirements, the absorption would not be complete; but if the quantity were much less than the maximum amount required, the absorption doubtless would be nearly complete.

Besides the above, soil conditions also influence the ability of a plant to effect a maximum absorption of poorly distributed fertilizer. Loss by leaching, fixation by the soil, bacterial action, etc., are all important factors which, as a rule, would tend to make the absorption of fertilizers less complete than would appear from the figures of this work.

The fact that in this investigation plants were able to effect a maximum absorption of all the nutrients only when all their roots were supplied with all the nutrients is suggestive for soil studies. As plants doubtless assimilate mineral nutrients from aqueous films surrounding soil particles, an apparently logical conclusion of the above fact is that a maximum absorption of nutrients would be possible theoretically only when all the films surrounding the soil particles contain all the nutrients.

REPORT OF THE HORTICULTURIST.

By C. F. KINMAN.

PINEAPPLES.

During the past two years work with pineapples has included a comparison of the effects of nitrate of soda and sulphate of ammonia in a complete fertilizer, fertilizer experiments carried on in cooperation with planters, and tests of general cultural methods and of varieties.

The results from the tests of nitrate of soda and sulphate of ammonia have been very striking (Pl. II, fig. 1). Both suckers and slips of plants, including Red Spanish and Cabezona, the common commercial varieties in Porto Rico, and the variety Trinidad, were set in beds which had been prepared in the usual way. Immediately after planting, all were given a light application of fertilizer containing 4 per cent nitrogen and 8 per cent phosphoric acid, and a few weeks later a mixture containing nitrogen, phosphate, and potash. The nitrogen was added in the form of nitrate of soda to duplicate plats, and sulphate of ammonia to others, while acid phosphate and sulphate of potash were applied to all plats. One planting was made in 1914 and one a year later, both in September, a time when rainfall is plentiful and thrifty seed plants available. After the seed plants had been harvested, they were left unplanted for a few days and became light green shaded with red from exposure. Twenty days after planting, it was noted that the pines on the plats fertilized with sulphate of ammonia had regained their thrifty dark-green color, but no change was noticeable in those on the other plats. The plants on the sulphate of ammonia plats continued their vigorous growth and maintained their healthy color throughout the year, but those on the other plats made a very slow growth and remained abnormal in color. The effects of the different forms of nitrogen on the growth of the plants was less marked on the Red Spanish variety than on the others. In no case did the plants supplied with nitrate of soda show any marked improvement over the unfertilized plants, and all were worthless from a commercial standpoint.

In March and April, the normal fruiting season for the Red Spanish variety at Mayaguez, 92 per cent of the plants given sulphate of ammonia bore fruits, all of which were of good marketable size, weighing from 2 to 4½ pounds, but only 34 per cent of the plants giving nitrate of soda produced fruits, the largest weighing only 1½ pounds and a large percentage less than half as much. Due to unfavorable weather conditions, few of the plants of the other varieties bore fruit, and all that fruited were in the plats fertilized with sulphate of ammonia.

From these results it is evident that, in soil similar to that at the experiment station at Mayaguez, nitrate of soda should not be used for fertilizing pineapples and that experiments should be conducted to determine its value in other soil types before it is used commercially.

COCONUTS.

The experiments in coconut fertilization discussed in former reports have progressed satisfactorily through the year. The plats given a complete fertilizer continue to produce much larger crops than those given an incomplete mixture, whereas in the group of plats where either nitrogen, phosphate, or potash is omitted from the fertilizer the yield is little heavier than that from the check plat. Although the complete fertilizer has greatly increased the number of nuts harvested, the average diameter of the nuts has remained practically the same in all plats throughout the experiments.

A number of coconut trees were selected for special study. The nuts from these individuals have been measured for several consecutive harvests to determine whether there is a constant relation between size and shape of husk and nut, whether the size of nut or thickness or shape of husk borne by a single tree varies at different times of the year, and whether there is any marked fluctuation in the size or shape of nuts or husks in the course of a few years. These measurements have been made during only a few harvests, but the results indicate that the product from a given tree varies little from harvest to harvest. Plantings have been made from seed of selected trees whose records of yields and of nut characteristics are at hand for the purpose of comparing the product of the new trees with their parents. As there is much to be learned in regard to the selection of seed nuts, the results of this work should be valuable to persons intending to plant coconut groves.

MANGOES.

A large number of mango trees of both imported varieties and seedlings from imported kinds are under observation at the experiment station. Of seedlings from 3 to 5 years old in the field, only those from the variety Cambodiana have made a uniformly thrifty growth (Pl. I, fig. 2). In rapidity of growth, color and shape of leaf, and general tree characteristics they are very uniform and can not be distinguished from grafted trees. In plantings from other varieties, including Amini, Sandersha, Totafari, Bulbulchasm, Mullgoa, and Alphonse, a small percentage of the trees have been thrifty; the others have made only a fair or poor growth. Seed of other varieties have been planted in the hope of finding some which will breed true from seed and thereby facilitate the distribution of superior mangoes over the island.

A few fruits borne by seedlings of Sandersha were large and similar in color, but somewhat different in shape, flavor, and color of flesh from the parent fruit. The seedlings from other imported varieties have not borne yet, but they are expected to fruit in one or two seasons.

During the year a large number of grafted and seedling trees of superior varieties have been distributed to planters, and the number in the orchards at the experiment station has been increased. As seedlings of the varieties Cambodiana, Sandersha, and Alphonse grow more rapidly than the common Porto Rican kinds, a result which may be accounted for by their larger seed, they are ready earlier for use as stocks. Practically all of them are large enough for this use before the severe winter drought starts, which is a decided advantage, owing to the difficulty of keeping the young plants from being seriously injured by thrips during the dry weather and thereby made useless for stocks.

The receptacles used for growing stock plants have been for the most part lightly made of 6-inch concrete tile 1 foot long and closed at one end by concrete except for the drainage openings. As these pots, being deep, are suited to the long taproot of the mango and hold a good quantity of earth, they are very satisfactory for this use.

Transplanting tests have resulted very satisfactorily with both nursery plants and older trees when the operation was performed at a time when the last flush was well matured and rainfall was abundant. Greatest success followed severe pruning, especially of trees a few years of age, and removal of a ball of earth with the roots. A number of trees of imported kinds were transplanted without loss after they were several years old and had borne two crops of fruit.

In testing the advisability of leaving long or short stems on the fruits when removing them from the tree, it was found that a stem somewhat longer than the fruit stock should be left if the fruit has not become fully ripe on the tree. The pressure of the juice is so high in fruits that have not softened that a stream is forced out through the large cells of the fruit stock, which, if the fruit stock is separated from the branch, leaves open passages into the base of the fruit through which infection enters after the fruits have cured a short time. When a stem slightly longer than the fruit stock is left this trouble is avoided. Lots of 100 each of long and short stemmed fruits of the Porto Rican type of mango known as Blanco were harvested when they were fully grown and had just started to soften, and were stored in the laboratory. In six days 12 long and 60 short stemmed fruits were decaying at the base. Of the long-stemmed specimens which decayed, probably the skin at the union of the stem and fruit had been broken by accident in handling.

MISCELLANEOUS INTRODUCTIONS.

Sweet potatoes.—Twenty varieties of American-grown sweet potatoes sent to the station in 1911 by the Bureau of Plant Industry, United States Department of Agriculture, have all lost their characteristic flavor, and at least some of them have developed a coarseness not common in the North. These importations are not, in general, superior in flavor or texture to the types which have been grown in Porto Rico over a long period of years. The Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, has sent to this station a new stock of the same varieties, which will be planted side by side with corresponding varieties of the former importation, to study further the apparent deterioration resulting from tropical conditions.

Among the common kinds of sweet potatoes found on the island one with superior qualities, known locally as mamey, is being propagated for distribution. Although it has borne small crops in the heavy soils of the experiment station and is reported as producing small crops in other localities, its excellent table qualities justify its extensive planting for home use.

Phaseolus mungo.—Two types of this leguminous plant, one of a luxuriant and one of a dwarfed habit of growth, which were received from the Philippine Islands, have proved very thrifty and prolific at Mayaguez when planted during the spring, although poor crops have resulted from summer, fall, and winter plantings. The cooked seed of this plant is palatable as food, and its heavy foliage makes it valuable as a soiling or cover crop. As *Phaseolus mungo* will probably grow well in most parts of Porto Rico, it should be tested thoroughly in all localities, and seed has been distributed to many planters for this purpose.

Banana.—A variety known as Hua Moa, which was sent to the experiment station from Hawaii several years ago and until the past two years has been given the same care as other varieties of bananas, produced unthrifty plants with small clusters and fruits. During the past two years good applications of stable manure have resulted in fair yields of good-sized fruits. The fruit of this variety is suitable for cooking, and it is thought by many Porto Rican families to be superior to other varieties for this purpose.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

The testing of coffee varieties new to Porto Rico is being continued, and such varieties as appear promising are being distributed widely.

During the past year a sufficiently extensive planting of Robusta coffee was made to demonstrate the possibilities of this type under local conditions. Its quality is considered inferior to that of the Arabian type grown in Porto Rico, but its heavier yield, judging from the few mature trees on the station grounds, makes it a promising crop for supplying a low-priced market. This coffee has matured much later than the native coffee, the main crop having ripened here in late winter and early spring rather than in autumn. This in one way is an advantage, as it furnishes employment to pickers in a dull season. The rank growth of the trees necessitates topping at 7 or 8 feet to facilitate picking.

The growth of San Ramon coffee has shown that it will succeed under local conditions. Its stocky form makes it desirable for planting in exposed situations. Where the typical Arabian coffee thrives, however, it should not be replaced by San Ramon, as the latter would probably bring a lower price.

The coffee received from the Congo as *Coffea dewevrei* has shown a very wide variation between individuals as regards vigor, growth, foliage, flowers, fruit, and time of maturing. Some trees are very vigorous and very prolific, and if the flavor of the product proves acceptable these will be valuable acquisitions. Individual records are being kept for the more promising trees.

The coffee known here as Murta has proved to be a mongrel. The inheritance of different forms in this coffee is being studied. Of 1,803 seedlings from unprotected blossoms, 543 were of the ordinary Arabian type and the others ranged from the Murta type to a small dwarf with many upright branches resembling a tiny green rosette (Pl. II, fig. 2). The total number of seedlings remaining when counted was approximately two-thirds of the number of seed planted. As some plants had been killed by a fungus before the count was made, and others doubtless were lost in cultivating, naturally the most vigorous type was found in excess of its true proportion. During the present blossoming season a number of branches were bagged to afford material for further study.

The experimental transplanting of coffee trees mentioned in the last report continues to show wide differences both in growth and yield as a result of the method followed. The results are considered of sufficient value to warrant a separate report.[1]

The fertilizer experiments continue to show beneficial effects, both on growth and crop, from the application of nitrogen. Cooperative fertilizer tests, in which nitrate of soda is used in different amounts, have been started on two coffee plantations.

A native tree of dwarf growth, *Erythrina corallodendron*, not hitherto used locally as coffee shade, is being tested for this purpose. Its easy propagation (nearly all cuttings striking root), its rapidity of growth, and its dwarf habit (permitting the lightening of shade without damage to the coffee below) are all points in its favor. Its development in full sunlight is much more vigorous than in shade. The question of new shade trees for coffee is an important one, as some of those used at present harbor pests very destructive to coffee.

Plantings without shade of different coffee varieties also are being made to compare their relative vigor in the open.

CACAO.

For a number of years records have been kept of the number of pods produced by individual cacao trees. These are being continued and are now being amplified by recording the weights of fresh pods, number of seeds, and weight of seeds. Of the cacao planting made in the spring of 1909, a little more than one-fourth of the trees produced no crop in the calendar year 1915. The others averaged nearly 10 pods per tree. In the planting made in 1903 about the same proportion of trees failed to produce, but the average yield from the fruiting trees was 6½ pods per tree. Attempts to propagate cacao from cuttings have been unsuccessful.

---

[1] Porto Rico Sta. Bul. 22 (1917).

VANILLA.

Encouraging results with vanilla have been obtained which show this to be a promising crop for Porto Rico. It requires careful attention and a great deal of labor, but with proper conditions large returns may be secured from a small acreage.

Fifteen out of eighteen 3-year-old plants of *Vanilla planifolia* came into production during the year. The yield was a little more than 5 pounds of cured vanilla, which sold at $2.50 per pound. Had an acre been planted the gross returns at the same rate of production would have amounted to nearly $400.

A Philadelphia firm, which deals in vanilla beans exclusively, wrote: "Regarding the vanilla sent us, value of same compares favorably with Bourbon or Java vanilla in same grades, or the vanilla produced in Guadeloupe. While the flavor is very pungent, being very similar to the Java variety, we believe that results from same would prove very satisfactory. Any well-cured vanilla, so long as it is of sweet flavor and sound keeping qualities, is always marketable."

The maximum production for a single vine was 131 pods; the average production, 68 pods. The longest pod measured 9 inches. As only a little over half the pods were 6 inches or more in length, and as one 8-inch pod weighs as much as two 6-inch pods and is also preferable to the latter, it is thought that the product would have been of higher grade had fewer pods been pollinated. As on most vines the number of blossoms which appear is far greater than the number of pods which the vine can produce, the size of the crop can be exactly regulated in the pollination. Experiments are planned to investigate this phase of vanilla culture.

Curing was effected by scalding, sweating, and then spreading the pods between the folds of a woolen blanket placed in the sun. This method was not entirely satisfactory, as many pods, through blistering, lost both in weight and appearance. Other methods will be tried with the new crop. The pods which cured well averaged 155 per pound for 6-inch pods, 112 for 7-inch pods, and 78 for 8-inch pods. For the crop now being produced by the same vines, the number of blossoms pollinated per cluster was greatly reduced, and the pods are far superior to those of the preceding crop.

In crossing vanilla species some very marked modifications in the shape of the resulting pod have followed the application of foreign pollen. The typical, normal, well-developed fruit of *Vanilla planifolia*, as exemplified by those produced at the station, is a long, fairly slender, trilateral capsule, tapering at the stem end, but carrying its fullness well down toward the blossom end. The fruit of the other vanilla species used in crossing with *V. planifolia* is of the "vanillon" type, a shorter, fleshier pod of fairly uniform thickness or tapering slightly near the blossom end. Where *V. planifolia* was fertilized with pollen of the vanillon type, the resulting pods were well filled out at the stem end and tapering at the blossom end, tending in this way to resemble the typical vanillon form. Where flowers of the vanillon type were fertilized with *V. planifolia* pollen, the resulting pods were larger at the blossom end than at the stem end, caricaturing, in a way, the *V. planifolia* form.

A new planting has been made for further tests of the effects of light and dense shading, different pruning systems, the removal of superfluous blossoms, and the pollination of few to many blossoms per cluster.

Vanilla will grow in quite heavy shade, but that this may easily become too dense for its best development was demonstrated by a planting made in a trench filled uniformly with forest trash and loosely bricked over, to which different degrees of artificial shade were supplied, ranging from a dense shade to full sunlight. In dense shade the vines were spindling, with long internodes, whereas in light shade or full sunlight their development was very vigorous, although the leaves on the unshaded vines were somewhat yellow. In some instances, where there is full exposure to the sun, the vines are burned at the point where they bend over the support, which severs the growth beyond this point from the rest of the vine. Where the shade plants have been severely pruned, the unaccustomed exposure to the sun under field conditions has worked serious damage to the vanilla, causing the burning and rotting of many leaves.

MAHOGANY.

The trees of *Swietenia macrophylla* continue to show adaptability to local conditions. In a planting made at the station the average height at three years from seeding was 16 feet, the maximum height 30 feet. Such rapidity of growth in a valuable timber recommends it for general planting.

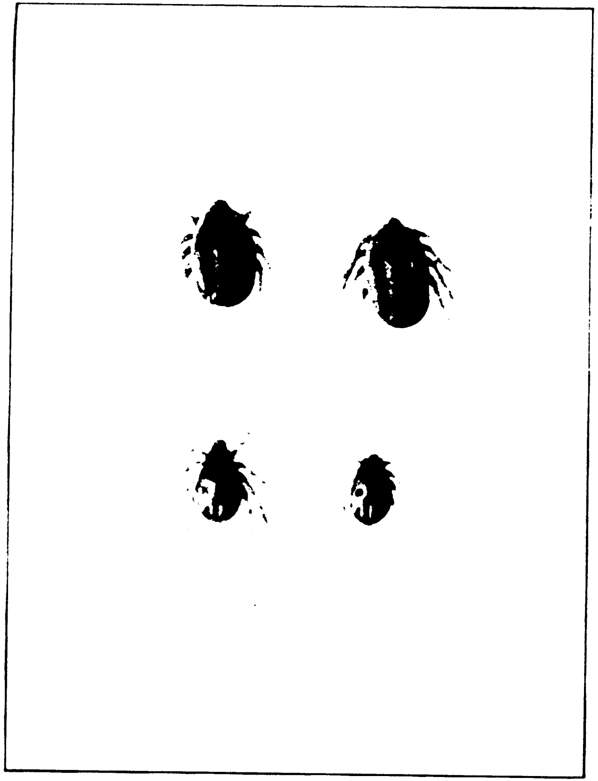

FIG. 1.—FEMALE AND MALE TICKS, UNENGORGED (× 5).

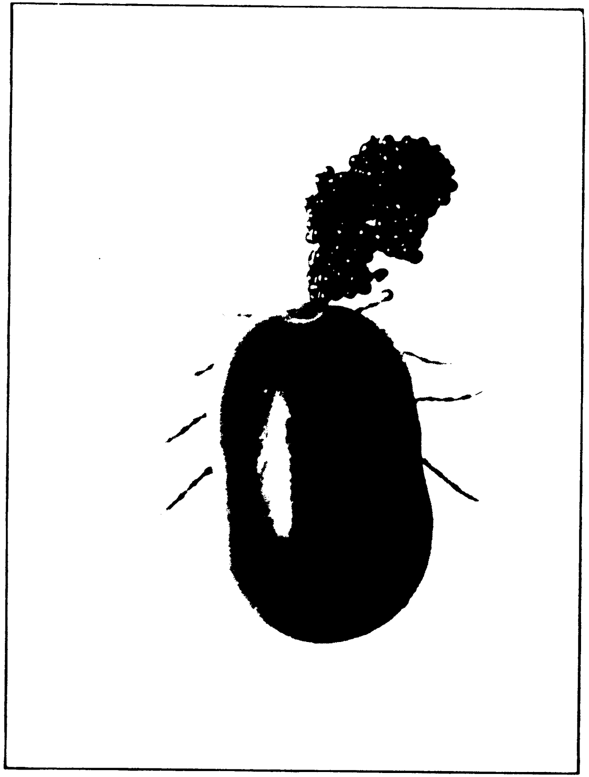

FIG. 2.—ENGORGED FEMALE TICK WITH NEWLY LAID EGGS (× 5).

CATTLE TICK (MARGAROPUS ANNULATUS AUSTRALIS).

REPORT OF THE ENTOMOLOGIST.

By R. H. Van Zwaluwenburg.

INTRODUCTION.

During the past year attention has been given chiefly to life-history studies of the changa and cattle tick. Work on the former has been brought to a close and is being prepared for publication. Experiments in trapping to reduce the numbers of the May beetle gave encouraging results and are being continued. Study on the coffee weevil was stopped temporarily by the comparative scarcity of the insect during the past year. Several press articles in both English and Spanish have been issued on beekeeping and on miscellaneous entomological subjects.

THE CHANGA.

The changa, or mole cricket (*Scapteriscus vicinus*), requires a year for the complete development of a generation. The egg stage requires about three weeks; the development from hatching to the final molt, some nine months; and the preoviposition period, between two and three months. Egg laying is most common during the spring months, and the night flight of adults most marked during November and December.

Adults captured at lights during October and November were more generally females than males. Should this disproportion between the sexes be constant, the value of using trap lights is obvious, especially since most of the females taken during the early fall have not yet laid their eggs. Observations on these points are being continued.

The most satisfactory control measure for the changa in small areas, such as garden plats, was found to be the use of poisoned bait. Persistent use of a mixture of flour or cornmeal and an arsenical will rid an area of the mole cricket and make successful gardening possible even in the most heavily infested areas. Repellents were found to be of little practical value. Flooding land for 24 hours or more may be practical in a few localities, as flooding forces nymphs and adults to the surface, where they fall a prey to insectivorous birds. The eggs of the changa fail to hatch after submersion for a day or longer.

CATTLE TICKS.

Two varieties of ticks infest cattle in Porto Rico. The more common is the Australian tick (*Margaropus annulatus australis*) (Pl. III). The typical *M. annulatus* of the Southern States is also present, but in much smaller numbers.

Control of the tick by starvation or dipping is dependent for success upon an exact knowledge of the parasitic and nonparasitic development of the acarid in the locality in which control work is to be done. This work is well under way, and data are being collected on the variation of the stages during the different seasons of the year.

At Mayaguez the Australian tick required 20 to 22 days for its development on the host during the fall months. Hence, if local eradication of the tick is attempted, applications of dips, sprays, or smears should be renewed about every three weeks to prevent the maturing of fresh generations. The minimum egg period under natural conditions was found to range from 36 days, beginning in February, when the average mean temperature was 74.7° F., to 23.5 days in September, when the average mean temperature was 79.6° F. The maximum starvation period of ticks hatching in April was found under natural conditions to be 94 days. Seed ticks protected from rain and direct sunlight had a maximum starvation period of 108 days.

MAY BEETLES.

White-grub injury to cane was especially frequent during the past year, at least on the western half of the island. Some preliminary experiments with trap lights were made which seem worth continuing. A 400-candlepower gasoline lamp, placed near the ground, was operated as soon as the spring flight of the beetles began, and it attracted the large common species of Lachnosterna, as yet undescribed, in large numbers. Males and females were captured in about equal numbers. Only about 17 per cent of the females had completed egg laying. Flight was confined to the early hours of the evening.

White-grub injury is more severe on ratooned cane. Although one of the most obvious control measures is the discontinuance of ratooning, this is not often desirable. The smaller mills, which are supplied by a comparatively small acreage of cane land, can ill-afford to lose the extra time required for a planted crop to mature. Experiments on ratoon cane with poisons and fumigants applied to the soil are now under way.

A CRICKET ATTACKING SEEDLINGS.

Seedlings of various kinds in the station plant houses were attacked severely by both the young and adult *Amphiacusta caraibea*, a dark-brown cricket, which is almost as common indoors as out. This insect is particularly fond of cool, moist locations. The female is wingless; the male is the common "grillo," which chirps so long and shrilly indoors. This species has been recorded as a household pest of foodstuffs. The damage done to plants is similar to that caused by cutworms and is even mistaken for the work of changas, for this cricket sometimes burrows beneath the plant and feeds from below in much the same way as the mole cricket. Screening seed beds does not afford complete protection, for the eggs are dropped through even a very fine meshed wire. Flour and Paris green were used successfully against this insect.

The egg of the cricket is subelliptical, with the ends somewhat pointed when laid. It is curved slightly on its axis and is yellowish white, with a dull, unmarked surface. Five eggs averaged 1.9 millimeters long and 0.7 millimeter wide. One female laid 59 eggs in captivity. The eggs usually are deposited singly in the upper inch of soil, but are sometimes dropped promiscuously on the surface. They hatch in about a month.

BEES.

The heavy summer and fall rains throughout the island resulted in a very poor honey crop during the past year. In the region of Aibonito, where, as a rule, five periods of guamá bloom may be counted upon annually, there were only two bloomings of which the bees could make any use.

Weighing experiments with shaded and unshaded colonies showed that shade is not so important a factor in honey production as it was thought to be, even in the hotter climate of the coast. No striking or consistent difference in production was evident between shaded and unshaded colonies. Colonies exposed to direct sunlight are not so tractable as those of the same race in shaded locations. Bottom-board ventilation is advisable with colonies both in sun and in shade.

Experiments are under way which lay particular stress on wax production rather than on honey production. With the present low prices of honey, and with the high cost of transporting such a bulky article from inaccessible interior points, increased wax production is a logical development of the beekeeping business.

There is at present a tendency toward a centralization of the industry. Small beekeepers are becoming discouraged at crop failures and low prices, and it seems to be only a question of time before beekeeping will be continued only on a comparatively large scale.

MISCELLANEOUS NOTES.

By far the most satisfactory spray material yet found for the majority of Porto Rican insects is the paraffin-oil emulsion used by the Bureau of Entomology, of the United States Department of Agriculture, in its work in Florida. It is more effective than homemade lime-sulphur and is much cheaper and less troublesome to prepare.

During the year there was a serious outbreak of the yellow aphid (*Sipha flava*) on young sugar cane at Ponce, Porto Rico. The growth of the cane was severely retarded, and in a few cases death resulted from the insect injury. The outbreak eventually was brought under control by natural enemies.

The only relative of the sawfly family recorded from the West Indies is *Sterictiphora zaddachi*, the larvæ of which feed on the leaves of sea-grape (*Coccoloba uvifera*) and icaco (*Chrysobalanus icaco*). The wings of the adult are transparent, with black veins; the body in life a bright crimson. The male is much smaller than the female and appears to have four antennæ, due to the forking at the third antennal segment. The eggs are subovate, with the base prolonged to form a short stalk. When first laid they are red, but as the embryo develops they change to pink. They are laid on the underside of the leaf in clusters of 26 to 31, the eggs in each cluster being regularly spaced. The egg averages about 1.8 millimeters high and 1.1 millimeters broad. The larvæ are gregarious and feed on the leaf with the terminal abdominal segments curled about the twig or leaf on which they rest, in the typical sawfly manner. When the larvæ are disturbed, the abdomen is curved forward over the head in a threatening manner. In the earlier stages they are a dirty white in color, with a pinkish tinge on the thoracic and last three abdominal segments. The last instar is very different in appearance and quite striking. The head and dorsum are shiny black; the first thoracic segment, the procoxæ, and the last abdominal segment, carmine; the sides of the body wine colored. Pupation takes place on the leaf, usually within a fold or roll. The tough brown pupa case, composed of a secretion mixed with leaf particles, is roughly oval, with one end truncate. Females averaged 16.7 days in the pupa, and males 18.8 days.

The termite mentioned in the 1915 report of the entomologist as tunneling in furniture and woodwork was named incorrectly there. The insect is a species of Cryptotermes.

REPORT OF THE PLANT PATHOLOGIST.

By E. W. Brandes.

INSPECTION TRIPS AND IDENTIFICATION OF PLANT DISEASES.

During the past year it was possible to make inspection trips which covered many of the important agricultural districts of the island. Many specimens of diseases of economic plants were collected and sent to the laboratory to be identified. Although no exact quantitative surveys were attempted, the trips were of great value in indicating the relative prevalence of the better known fungus diseases. An index was thus obtained to the logical order of procedure in undertaking investigations of the various diseases. A number of new dis-

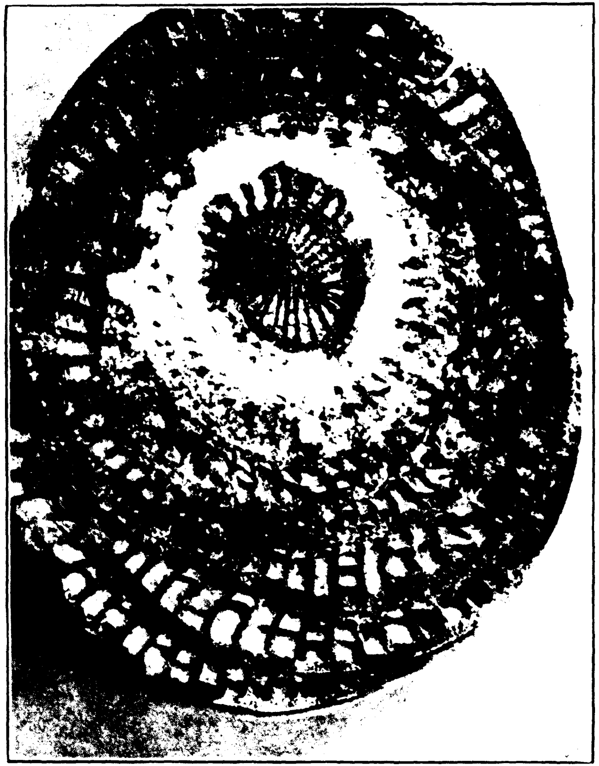

FIG. 1.—SECTION OF BANANA STEM SHOWING RING OF FUNGUS MYCELIUM.

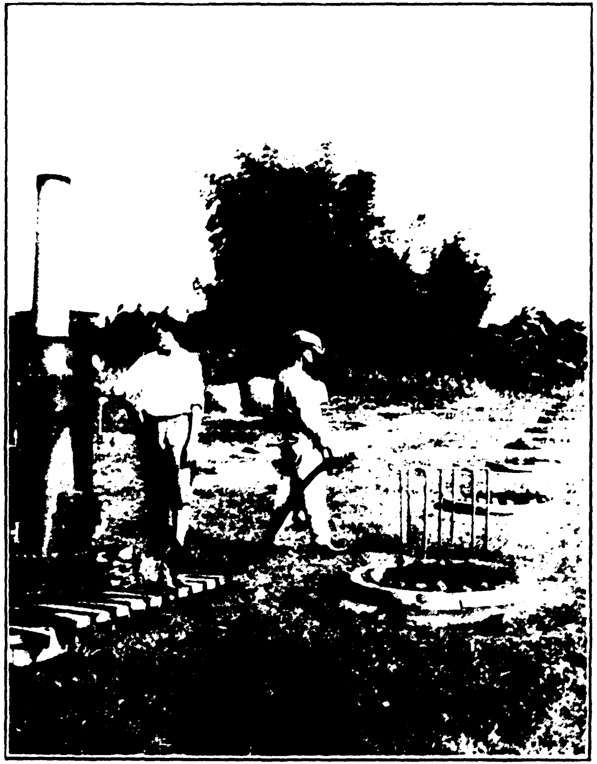

FIG. 2.—METHOD OF STERILIZING SOIL FOR BANANA PLANTS.

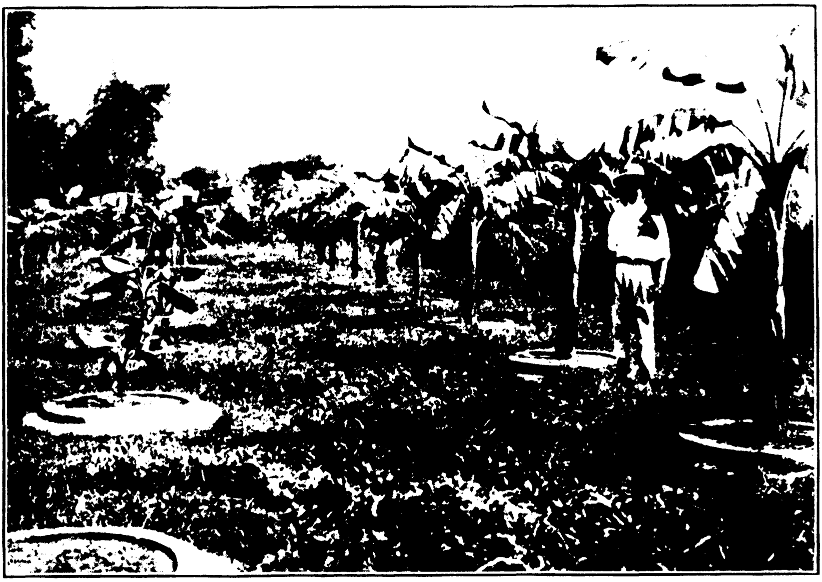

FIG. 1.—BANANAS GROWN IN STERILIZED SOIL; LEFT INOCULATED WITH PURE CULTURES OF FUSARIUM, RIGHT UNINOCULATED.

FIG. 2.—EXPERIMENTAL PLATS IN BANANA DISEASE CONTROL.

cases have been discovered, and previously described fungi have been found on new hosts. Many planters have taken advantage of the opportunity to send in specimens of plants attacked by troublesome diseases. These have been identified whenever possible, and a detailed account of the treatment, if this has been worked out, has been sent to the planter.

HERBARIUM.

The old station herbarium, which had not been added to for some time, has been taken in charge and renovated by this office and numerous additions made to it. It now contains about 1,000 numbers, representing over 100 families. A more orderly arrangement of folders in the cases has been adopted and the entire collection indexed. Most of the new collections have been identified, and some progress has been made in determining old specimens. A collection of fungi has been started and now consists of about 300 named species. This is indexed according to the plan used for the general herbarium. A host index of parasitic fungi is being maintained. Some exchanges of fungi and flowering plants have been made with the Insular Experiment Station at Rio Piedras and with the Brooklyn Botanic Garden, Brooklyn, N. Y.

PLANT-DISEASE SURVEY.

The station has undertaken to cooperate with the Bureau of Plant Industry of the United States Department of Agriculture in the plant-disease survey which is being conducted over the mainland of the United States and its insular possessions. As few data have been accumulated as yet, it is to be expected that the benefit of the work will become more apparent after records have been kept for a number of years.

BANANA WILT (PANAMA DISEASE).

The well-known and much-dreaded banana wilt, or Panama disease, which has been so destructive in Panama, Costa Rica, Cuba, Jamaica, and other countries in the American Tropics, has been present in the banana plantations of Porto Rico for many years. Here it has been especially injurious to the Chamaluco variety, and the appearance of diseased plants has been described by G. L. Fawcett, former plant pathologist of this station.[1] It agrees quite closely with descriptions of the disease as it occurs in other countries. The disease has been assumed to be caused by a parasitic fungus of the genus Fusarium, which has been found by several investigators to be associated with the disease. However, no formal proof of causation has come to the attention of the writer. In 1908, Erwin F. Smith[2] obtained a Fusarium from the xylem of banana plants suffering from typical Panama disease, cultures of which were used to inoculate petioles of banana plants in greenhouses in Washington, D. C. The Fusarium was found to occupy the vascular bundles 7 feet from the point of inoculation, producing the characteristic stain. Before secondary signs appeared the experiment was broken off by the removal of the plants to a new greenhouse. After remaining dry on a bench for several months, the rootstocks were planted and grew without the development of secondary signs. Dr. Smith named the organism *Fusarium cubense.* On account of the pressure of other work no further experiments were made, and no published technical description of the pathogene has appeared.

---

[1] Porto Rico Sta. Rpt. 1915, pp. 36–41.

[2] Science, n. ser., 31 (1910), No. 802, pp. 754, 755.

As a result of experiments performed at this station during the past year, it is now possible to furnish formal proof of the pathogenicity of the parasite. Cultures of the Fusarium were obtained easily from banana plants of the Chamaluco variety which showed typical symptoms of the wilt disease. A method of isolation found uniformly successful was to cut a cross section of the pseudostem 2 inches thick from a point about 4 feet above the surface of the ground, immerse for 10 minutes in 1 to 1,000 corrosive sublimate solution, wash five minutes in sterile distilled water, and put away in a sterile moist chamber. A luxuriant fungus growth usually appeared in about three days, springing from the band of diseased tissue found typically in plants badly attacked by this fungus (Pl. IV, fig. 1), from which, it was possible to obtain a pure culture by plating out spores. A microscopical examination of the fungus showed it to be a Fusarium. In the course of the work, this fungus has been isolated nearly 50 times. No other fungus has been isolated from banana plants affected with this disease. A Fusarium indistinguishable in its cultural characters from the one in question has frequently been isolated from the soil of affected banana plantations and adjacent fields at a depth of 4 inches.

Experiments on the etiology of the disease were begun in January 1916. Thirty cylindrical cement tiles, 3 feet in diameter and 4 feet deep, were sunk into the ground, with a rim projecting 4 inches above the surface, and filled with a mixture of river sand and clay loam. The soil in 20 of them was sterilized with steam from a specially constructed apparatus connected with a steam boiler (Pl. IV, fig. 2). The soil in 10 of the sterilized tiles was inoculated with pure cultures of the Fusarium, the other 10 being left for checks. Healthy suckers from Naguabo, Porto Rico, were planted in all of the tiles. Eight months from the time of planting all of the plants growing in inoculated soil were badly diseased and stunted, and two of them were dead. All of the check plants growing in sterilized soil were healthy and had made a remarkably vigorous growth. The difference between the two rows is shown conspicuously in the accompanying illustration (Pl. V, fig. 1). The check plants averaged more than ten times as large (by weight) as those grown in inoculated soil. A fungus was readily reisolated from the artificially inoculated plants, which, when grown in pure culture, proved to be identical in cultural characters with the one used for inoculation. The internal structure of the check plants cut down for examination showed absolutely no sign of disease. The Fusarium causing this disease belongs to the section Elegans, provisionally erected by Wollenweber to facilitate the division of the genus Fusarium into more or less natural groups. There is no reason for believing that it is different from the fungus found by Dr. Smith in wilted banana plants from Cuba and designated by him *Fusarium cubense.*[1]

However, since no ample technical description of the organism has been published, the following description is given of it:

Fusarium cubense Smith. Sclerotia indigo-blue, developing from flesh-colored plectenchyma, irregular, nodule-like, 1 to 4 mm. in diameter, on potato plugs, 12 days old. Pionnotes, reduced, produced on agar slants, hyaline at first, becoming white, powdery. Sporodochia, 2 to 5 mm. in diameter, produced on agar slants in 12 to 20 days, light salmon color. Pinkish salmon color becoming tinged with blue in age produced on steamed rice grains, Cultures in confined space observed to give off a suffocating gas but no strong aromatic odor, as is the case with some Fusaria. Growth on potato plug rapid, luxuriant, dead white, aerial, at first producing only microconidia in great abundance from simple aerial conidiophores. Microconidia continuous or 1-septate, oval, average 6.65 by 3.5μ. Macroconidia, from sporodochia sickle-shaped up to 95 per cent 3-septate, average 33.5 by 3.8μ, range 20 to 40 by 3 to 5μ up to 5 per cent 4-septate, average 38.8 by 4.1μ; occasional 1, 2, and 5 septate macroconidia. Chlamydospores mostly terminal, sometimes intercalated in hyphæ, abundant on potato plug culture seven weeks old, mostly single, sometimes paired, few short chains. Single spores average 9.45 by 7μ, paired spores average 11.2 by 7.5μ.

The fungus is seen to be related closely to *Fusarium vasinfectum.*

A more detailed account of the investigations carried on in connection with this disease will be given in a separate publication, together with the results of experiments in control measures, which have not yet been concluded (Pl. V, fig. 2).

In connection with the study of the life history of the above organism, some 35 fungi, many of which appear to be forms of well-known pathogenic habit, were isolated from the soil in and near banana plantations. A description of these also will appear in a separate paper.

---

[1] In reply to a letter including a description of the organism, Dr. Smith has written: "Respecting the inquiries in your letter of Feb. 6, I think it is all right for you to go ahead on the assumption that the disease you have is the Cuban one. I have seen nothing in my researches on it which contradict any of the statements in your letter."

○

NOV 26 1918

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1917.

▼

Issued September 20, 1918

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Agronomist in Charge,
Mayaguez, P. R.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1917.

▼

Issued September 20, 1918

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1918.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*
WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

D. W. MAY, *Agronomist in Charge.*
P. L. GILE, *Chemist.*
C. F. KINMAN,[1] *Horticulturist.*
W. V. TOWER,[2] *Entomologist.*
H. E. THOMAS, *Plant Pathologist.*
H. C. HENRICKSEN, *Specialist in Farm Management.*
W. A. MACE, *Agricultural Technologist.*
T. B. MCCLELLAND, *Assistant Horticulturist.*
J. O. CARRERO, *Assistant Chemist.*
W. P. SNYDER, *Assistant in Plant Breeding.*
C. ALEMAR, Jr., *Clerk.*

LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., December 31, 1917.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1917.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

---

[1] Transferred to U. S. Department of Agriculture, Bureau of Plant Industry, Apr. 17, 1918.

[2] Appointed Mar. 1, 1918, to succeed R. H. Van Zwaluwenburg, transferred to U. S. Department of Agriculture, Bureau of Entomology.

CONTENTS.

Page.

Report of the agronomist in charge 5
  Introduction 5
  Lines of work 5
  Fruit 6
  Food crops 7
  Cooperative and demonstration work 7
  Virgin Islands of the United States 8
Report of the chemist and assistant chemist 9
  Analytical work 9
  Phosphates in Porto Rican soils 9
  Lime-induced chlorosis 10
  Absorption of nutrients as affected by distribution of nutrients to the roots 10
  Relative efficiencies of sulphate of ammonia and nitrate of soda for rice 10
  Chlorosis of sugar cane 10
    Survey of soils producing chlorotic cane 11
    Examination of green and chlorotic canes for fungi 14
    Ash analyses of green and chlorotic leaves 14
    Treatment of chlorotic cane with iron and stable manure 16
    Discussion of results 19
Report of the horticulturist 20
  Sweet potatoes 20
  Coconuts 21
  Mangoes 21
  Citrus fruits 22
  Miscellaneous introductions 22
Report of the assistant horticulturist 23
  Coffee 23
  Cacao 26
  Vanilla 26
Report of the plant pathologist 28
  Vegetable diseases 28
  Vanilla diseases 29
  Citrus diseases 29
Progress report on citrus scab 30
Report of the entomologist 31
  The cattle tick 31
  A new corn pest 33
  Miscellaneous 33
Report of the assistant in plant breeding 35
Report of the specialist in farm management 36
Report of the agricultural technologist 38

ILLUSTRATIONS.

Page.

PLATE I. Emergency food production staff 8

II. Fig. 1.—*Crotalaria saltiana*, a green-manuring crop. Fig. 2.—Fertilizer experiments with coffee 24

III. Fig. 1.—*Corypha* sp., an introduced palm. Fig. 2.—Red Crillo cacao tree 5 years from seed 24

IV. Fig. 1.—Cacao plantation. Fig. 2.—Emergency food production meeting, Sabaña Grande, P. R. 36

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1917.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. May.

INTRODUCTION.

The experiment station in Porto Rico, established shortly after the transfer of the island to the United States, is maintained by the Federal Government but has been equipped with lands and buildings by the insular government. Its work has been varied in character. While it has sought to improve the old industries, such as the production of sugar cane, coffee, and tobacco, it has also endeavored to diversify the agriculture by introducing and promoting in every way possible the production of new and promising crops of other tropical countries. Movements have been started under the American protectorate for the establishment of experiment stations in Santo Domingo and Haiti, a former member of the staff of the Porto Rico Station having gone to Santo Domingo to inaugurate the work.

LINES OF WORK.

The Porto Rico Station has given special attention to the study of soils, their types, physical characteristics, and fertilizer requirements. This work, which has been reported upon from time to time, is based on laboratory and plat experiments at the station and cooperative field trials in various sections of the island. Porto Rican soils have been found deficient in the three elements of fertility usually lacking, nitrogen, phosphorus, and potash, especially the first. The fertilizer bill of the island has grown from practically nothing at the time of the American occupation to $2,000,000 annually. While this expenditure has shown large returns on the investment, the station has sought to reduce it by finding local sources of the fertilizing elements.

The importance of growing legumes as cover crops in all systems of rotation is being especially impressed on Porto Rican planters. With a continuous growing season and a large number of leguminous plants, native and introduced, as the cowpea maturing in 70 days, the velvet bean in 8 months, and leguminous trees like the agati in 2 years and others in 10 to 50 years, there should be no idle land in Porto Rico and no break in crop following crop throughout the year. In many cases one crop can be planted before another is removed, and sometimes two, as corn and beans, can be planted together to their mutual advantage, the corn supporting the beans and in return obtaining some of the nitrogen which the beans secure from the air. Further study of the planting of legumes and foresight in intercropping and diversification will result in time in all the necessary nitrogen being locally secured, thus eliminating cash expenditure for the most expensive fertilizing element while improving the physical condition of the soils and adding crops that will in time bring large returns.

During the year the work of surveying and listing the bat guanos in the caves of the island was completed, and studies were made of their value and the availability of their phosphates. This investigation has resulted in a greatly increased use of the deposits. It is hoped at a future date to take up work with the phosphate deposits in Mona Island, which lies in the channel 40 miles west of Porto Rico and belongs to her. This work, as well as that of studying methods for obtaining potash from the mother liquor from the salt works at Salinas, has had to be temporarily postponed.

FRUIT.

The fruit industry has shown commendable progress during the year, the exports running over $3,000,000. Much fruit, especially oranges and grapefruit, goes to waste on the island, due in great part with wild oranges to inaccessibility of ports of shipment and with grapefruit to imperfections and oversize.

Efforts are under way to try out on a commercial scale certain methods developed by the Bureau of Chemistry, United States Department of Agriculture, for bottling and shipping the juice of oranges and grapefruit. The custom of serving these juices in the glass is increasing at soda fountains, in hotels, and on dining cars, and laboratory tests indicate that the demand can be successfully met with bottled juices. Not only will fruits discarded for off-size or blemish of the skin be saved, but freight rates will be lowered, loss by decay in transit will be prevented, and a higher average market for the whole fruit will result, as the low-grade stuff will be bottled at the packing houses and not put on the market to depress the general quality and price of the crated goods.

The principal diseases which citrus growers have to combat are scale and scab. Methods for keeping scale in check are pretty well known and generally followed. Scab is a more serious problem, as its cause is somewhat obscure and methods of control have not as yet been definitely determined. During the year Dr. L. R. Hesler, of Cornell University, spent three months on the island studying this trouble, but a pathologist should be secured to devote his entire time to the problem and for this purpose additional appropriation is desired.

FOOD CROPS.

Besides the big staple crops, sugar, coffee, tobacco, and fruit, the station has given especial attention to the minor food crops. The uncertainty of securing imported supplies caused by shipping conditions after the United States entered the war made it necessary to pay particular attention to food production in Porto Rico, to provide material not only for exchange with other countries but for sustaining the population in case the island were cut off from the outside world. Special attention was given to the growing of beans, corn, and rice; but statistics of all the minor food crops were gathered, the first work of the kind in the history of the island.

In 1916 Porto Rico imported more than $800,000 worth of beans, which form a large part of the food of the population. During the present year, not only has the island grown enough beans to supply its own needs, but it has had a surplus to export.

The crop of corn is the largest yet produced in Porto Rico, the increased production having been accompanied by improvement in quality brought about by seed selection and better cultivation. The active propaganda carried on to secure increased production has included advice as to the milling of corn for use as a staple article of diet. This grain is not generally consumed as food at present, and efforts are being made to have it enter more largely into the dietary of the people to take the place of a part of the large amounts of imported wheat flour.

There has been an increased production of rice, and one planter growing it is employing machinery for seeding, flooding, harvesting, and thrashing. C. E. Chambliss, of the Office of Cereal Investigations of the Bureau of Plant Industry, from a survey of rice growing in Porto Rico made during the past summer, estimates that the island can produce at least one-half of the $5,000,000 worth of rice now imported annually. As a result of Mr. Chambliss's findings, cooperative work is under way between the Office of Cereal Investigations, the Porto Rico Experiment Station, and planters in different sections who make field trials in growing rice. Several tons of the best seed rice has been shipped and the latest rice machines purchased, and representative planters have agreed to put in several acres of the crop in their respective localities to give the industry a thorough try out. Every condition seems favorable to securing increased production of this crop and permanent utilization of thousands of acres of land now idle and unproductive.

COOPERATIVE AND DEMONSTRATION WORK.

With the increased resources of the station it has become possible to extend the work to other parts of the island, and cooperative and demonstration work has been undertaken in many localities.

Through the cooperation of the insular food commission, an active campaign was organized in May, 1917, to stimulate food production in Porto Rico, so as to render the island less dependent on the mainland for maintenance. (Pls. I and IV, fig. 2.) For convenience, the field of endeavor has been divided along two lines, H. C. Henricksen having direction of the work with fruits and other crops on the northern side of Porto Rico and W. A. Mace the crop investigation and demonstration on the southern and western part of the island.

VIRGIN ISLANDS OF THE UNITED STATES.

Shortly after the transfer of the Danish West Indies to the United States, Gov. James H. Oliver requested the Department of Agriculture to have a survey made of the agricultural possibilities of the islands and to outline the best methods for their development. The writer was detailed for the work. He visited St. Thomas, St. Croix, and St. John, traveling over them and conferring with planters engaged in the various lines of production.

Of the three principal islands of the group, St. Croix is the largest, being 21 miles long and an average of about 6 miles wide, as well as the best from an agricultural point of view, having a fertile soil easily worked. The leading crop is sugar cane, with sea island cotton second. The island is deficient in moisture, the average rainfall for 60 years being slightly under 50 inches, an amount insufficient for the maximum production of sugar cane. Fertilizers have not been generally successful, owing, it is claimed, to the fact that there is not enough moisture present in the soil for their ready solution and use by crops.

St. Thomas, second in size, is about 14 miles in length and contains the excellent harbor that lends especial value to the group. It is hilly and not well watered, but grows excellent grasses. Some trucking is done in the valleys, the produce being sold locally and for supplying ships.

St. John, a mountainous island about 12 miles long, is third in size and produces principally cattle, oil of bay, and excellent guinea grass, the sole food of the cattle. Once the seat of a flourishing agriculture, as shown by the remains of old mansions and cane mills, St. John lost its prosperity with the freeing of the slaves, and the island is now occupied by about 1,000 people, for the most part making a precarious living from fishing and trading with the port of St. Thomas.

An experiment station was established by the Danish Government in St. Croix on 215 acres of fertile land with fair equipment and buildings, but the income now secured from local sources is not sufficient for proper maintenance. No greater good could be done the Virgin Islands than to maintain an efficient experiment station.

EMERGENCY FOOD PRODUCTION STAFF.

In St. Croix an examination should first be undertaken of the character and amount of the underground waters with the view of utilizing them for irrigation. With enough irrigation water added to the rainfall to produce maximum crops, the production could be increased to an enormous extent. Following the use of more water, fertilizer experiments should be undertaken to determine the needs of the various crops and the types of soil. On St. Thomas, work in producing vegetables and minor crops for local consumption and for ships' stores should be inaugurated, with especial attention given to sanitary milk production. Certain new crops should be tried out on St. John and considerable demonstration work done among the people with the object of restoring the agriculture of the island and the prosperity of its people.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. GILE and J. O. CARRERO.

Work on the efficiencies of various phosphates in Porto Rican soils received most attention during the past year. It was possible, however, to continue an investigation of chlorosis of sugar cane that has been in progress for some time and to commence two other studies of less scope.

The work done on the chlorosis of sugar cane is given below in detail. In its present form it was completed sometime ago, but reporting the results was delayed pending the investigation of an apparently contradictory result secured in the ash analyses.

ANALYTICAL WORK.

Some 300 samples were analyzed the past year, the greater number being plants in which one or more mineral constituents were determined. A considerable number of miscellaneous materials sent to the laboratory for identification were tested qualitatively. These included chiefly samples of guanos, pyrites, manganese, and kaolin.

PHOSPHATES IN PORTO RICAN SOILS.

Thus far results have been secured from three soils on the relative efficiencies of different phosphates, on the degree that liming affects efficiencies, and on the rate at which phosphoric acid becomes unavailable by remaining in the soil. Work with four other soils is in progress and others will be studied as rapidly as facilities permit. In the completed tests, 200 or more pots were used with each different soil. It is hoped to test all the main soil types on this scale and some less important types less extensively.

LIME-INDUCED CHLOROSIS.

The past year, results of direct experiments and related studies showing the cause and nature of lime-induced chlorosis were being prepared for publication, but it was found necessary to conduct another experiment. The work will doubtless be finished the coming year.

ABSORPTION OF NUTRIENTS AS AFFECTED BY DISTRIBUTION OF NUTRIENTS TO THE ROOTS.

This work is an extension of that published last year, which showed how the absorption of a nutrient was affected by the number of roots supplied with the nutrient. The first study considered the absorption of various elements when part of the roots were maintained in a complete nutrient solution and part in a nutrient solution lacking one element. In the present work the absorptions of nitrogen, phosphoric acid, and potash are measured when the roots of the plant are divided between two incomplete solutions and when the roots are divided between three incomplete solutions. This study should be completed the coming year. It throws some light on factors governing the absorption of mineral nutrients.

RELATIVE EFFICIENCIES OF SULPHATE OF AMMONIA AND NITRATE OF SODA FOR RICE.

A vegetation experiment in pots was conducted to test the relative efficiencies of sulphate of ammonia and nitrate of soda for rice under several conditions. As the plants seemed to absorb or utilize the two forms of nitrogen at different times, it was necessary to conduct an experiment to observe the influence of time of application on the amount of nitrogen recoverable in the crop. These two tests have just been completed and will be published shortly unless it seems advisable to prosecute the work further.

CHLOROSIS OF SUGAR CANE.

In the southern part of the island from Yauco to Salinas there are numerous restricted areas where sugar cane suffers more or less from chlorosis. The size of markedly chlorotic areas varies from a few stools to an acre. There are, however, some fields of many acres near Santa Isabel which are irregularly affected, a large portion of the cane being more or less chlorotic at times.

In most pronounced cases of this chlorosis the leaves are of normal size but creamy white in color. In less advanced stages the midrib only may be green, or the midrib and veins green with the parenchymous tissue colorless, giving the leaf a striated appearance. Cane so affected often dies but more frequently recovers most of its green color only to lose it again later. The chlorosis may appear at any stage of growth from two months after planting up to the time of arrowing. Ratoons seem to suffer more than plant cane, and B 1753 is a little more resistant than Cristalina, Otaheite, or B 208. This same chlorosis has been observed in Hawaii and some islands of the West Indies, but never over any great area.

In a few cases the chlorosis appears in the same spot year after year and the cane is more or less affected throughout the period of growth. Many of these areas are no longer planted. Sometimes certain spots in a field are markedly chlorotic one year and very little affected another year. In nearly all cases under observation the degree to which the cane was affected varied greatly at different times during the growth of the cane. The variation in degree of chlorosis did not correspond to any particular age of the cane but did seem to show some correspondence with activity of growth and rainfall.

The marked similarity of this chlorosis of sugar cane to that previously observed in pineapples[1] indicated that cane chlorosis was probably also associated with an excessive amount of carbonate of lime in the soil. A soil survey was accordingly made of the principal areas where cane was affected.

SURVEY OF SOILS PRODUCING CHLOROTIC CANE.

Samples of the first and second foot of soil were taken from areas where cane was markedly chlorotic and from the nearest areas where cane was perfectly green at that time. These comparative samples were in most cases only a few yards apart. While there was a very great difference in color and size between the green and chlorotic cane at the time the samples were taken, it should be borne in mind that in some cases this difference doubtless diminished later, the green cane becoming chlorotic for a time or the chlorotic cane becoming greener. On soil No. 452, the cane was green and well grown, although in previous years there had been some chlorotic patches in this field.

Samples marked "always green" in the table given below were from fields near the chlorotic cane which, in the long experience of the planters, were known never to have produced chlorotic cane. Only three of these samples were taken, as in most cases it could not be said that the cane on adjacent areas never showed slight chlorosis in small patches. No attempt was made to analyze soils from all fields which produce green cane.

Besides the analysis of samples by the usual method of acid digestion, determinations were made of the water-soluble constituents. The analytical results are given in the table following.

---

[1] Porto Rico Sta. Bul. 11 (1911).

Analyses of soils producing green and chlorotic cane.

Laboratory number.	Locality.	Condition of cane.[1]	Acid analysis.											Water analysis.						
			Insoluble matter.	Volatile matter.	Alumina (Al_2O_3).	Ferric oxid (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Potash (K_2O).	Phosphorus pentoxid (P_2O_5).	Carbon dioxid (CO_2).	Carbonate of lime ($CaCO_3$).	Nitrogen (N).	Bicarbonate (HCO_3).	Carbonate (CO_3).	Chlorid (Cl_2).	Sulphate (SO_3).	Lime (CaO).	Magnesia (MgO).	Total salts as sulphates.
	Ponce, Hacienda Mercedita, Field No. 3, Isabela poniente:		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
389	Soil	C	31.44	30.11	4.21	5.70	28.12	0.33	0.48	0.21	....	42.25	0.16	0.0721	0	0.0057	0.0073	0.0249	0.0045	0.1190
390	Subsoil	......	24.46	32.88	4.06	3.34	34.58	.20	.34	.07	26.52	60.28	.16	.0615	0	.0062	.0075	.0196	.0041	.0997
391	Soil	G	33.89	29.14	4.34	4.10	26.11	.22	.57	.16	19.72	44.82	.22	.0655	0	.0027	.0065	.0198	.0042	.1122
392	Subsoil	......	32.56	28.76	5.98	4.05	27.21	Trace.	.63	.05	20.20	45.91	.01	.0765	0	.0054	.0087	.0207	.0054	.1267
400	Soil	G	28.39	31.48	5.08	3.75	29.23	Trace.	.16	.14	21.69	49.19	.20	.0721	0	.0044	.0029	.0249	.0034	.1150
401	Subsoil	......	19.53	35.52	3.85	2.56	36.79	.91	.25	.13	27.91	63.43	.14	.0713	0	.0052	.0058	.0253	.0022	.1114
	Ponce, Hacienda Mercedita, Field No. 1, Logroño:																			
420	Soil	C	22.39	34.51	4.67	1.89	35.14	.63	.28	.26	25.57	58.11	.29	.0638	0	.0045	......	.0509	......	.0827
421	Subsoil	......	12.01	39.19	2.40	1.70	43.91	.84	.06	.14	35.19	79.98	.12	.0331	0	.0062	......	.0452	......	.0801
422	Soil	G	23.73	34.53	4.59	3.40	32.19	1.32	.05	.19	26.81	76.70	.33	.0683	0	.0045	......	.0529	......	.1021
423	Subsoil	......	21.45	34.40	4.42	3.82	34.21	1.56	.04	.10	24.85	56.49	.23	.0637	0	.0072	......	.0484	......	.0935
	Santa Isabel, Hacienda Florida:																			
386	Soil	C	57.47	15.66	8.61	7.82	8.98	1.26	.46	.19	5.15	11.70	.21	.0780	0	.0068	......	.0238	.0021	.1329
387	Subsoil	......	53.81	......	8.91	7.93	12.84	1.08	.29	.13	9.63	20.91	.06	.0629	.0017	.0061	......	.0145	.0041	.1168
388	Soil	G	63.50	12.02	10.04	8.55	5.53	.37	.40	.12	2.30	5.22	.16	.0748	0	.0048	......	.0210	.0080	.1074
402	Subsoil	......	56.45	13.40	11.33	5.02	9.47	3.03	.05	.25	5.84	13.28	.04	.0603	0	.0044	.0018	.0117	.0072	.0900
403	Soil	C	57.67	15.08	6.90	6.62	9.80	3.30	.35	.13	5.83	13.23	.20	.0768	0	.0045	.0016	.0260	.0052	.1348
404	Subsoil	......	53.73	15.97	9.05	4.35	13.08	3.47	.20	.21	9.28	21.10	.07	.0623	0	.0062	.0051	.0170	.0084	.1158
405	Soil	G	65.56	11.07	9.48	7.97	2.33	1.94	.50	.20	.13	.29	.16	.0618	0	.0053	.0153	.0212	.0049	.1086
406	Subsoil	......	57.50	13.04	8.51	7.66	9.33	2.37	.30	.15	5.46	12.50	.06	.0582	0	.0044	.0195	.0197	.0042	.0979
407	Soil	AG	66.80	8.69	9.82	8.40	3.18	2.44	.42	.05	.07	.16	.13	.0742	0	.0059	.0133	.0235	.0046	.1123
408	Subsoil	......	64.14	10.42	9.37	7.88	4.52	2.37	.60	.30	1.38	3.13	.08	.0495	0	.0044	.0146	.0189	.0045	.0809
	Santa Isabel, Central Cortada, Field No. 11, Mejias:																			
409	Soil	C	48.94	22.28	7.15	5.63	10.56	5.03	.34	.46	6.87	16.79	.32	.0814	0	.0091	.0127	.0226	.0078	.1527
410	Subsoil	......	28.23	30.50	9.15	3.65	27.58	1.89	.49	.07	12.54	28.52	.09	.1262	0	.0171	.0297	.0116	.0060	.1898

	Santa Isabel, Central Cortada, near mill:																			
411	Soil	AG	55.74	12.84	14.54	9.89	3.08	3.62	.23	.06	Trace.	Trace.	.22	.0443	0	.0064	....	.0242	....	.0624
412	Subsoil	......	60.67	11.83	11.94	9.79	2.56	2.46	.31	.13	Trace.	Trace.	.004	.0481	0	.0053	....	.0298	....	.0730
	Santa Isabel, Central Cortada, Field No. 0, Carretera:																			
470	Soil	C	42.98	23.99	13.19	5.52	11.07	2.53	.25	.22	10.60	24.09	.11	.0655	0	.0065	.0135	.0305	.0131	.1719
471	Subsoil	......	33.32	25.95	11.30	5.64	23.70	1.29	.11	.06	19.23	43.70	.03	.0520	0	.0050	.0078	.0145	.0086	.0852
	Ponce, Hacienda Amelia, Field No. 1052:																			
424	Soil	C	41.13	24.10	2.70	9.11	19.41	2.65	.30	.36	11.35	25.77	.28	.0778	0	.0056	.0037	.0323	.0035	.1304
425	Subsoil	......	36.76	25.06	5.23	5.81	23.77	2.85	.10	.19	19.53	44.38	.15	.0560	0	.0055	.0038	.0265	.0039	.1172
	Ponce, Hacienda Amelia, Field Guirivaldi:																			
426	Soil	G	60.54	14.10	9.22	8.24	3.68	2.14	.44	.18	Trace.	Trace.	.32	.0678	0	.0056	.0026	.0236	.0024	.1107
427	Subsoil	......	63.39	12.68	9.32	8.25	4.56	2.32	.24	.15	2.95	6.70	.16	.0536	0	.0042	.0019	.0213	.0028	.1032
	Yauco, Hacienda Montserrate, Field No. 48:																			
428	Soil	C	47.77	17.74	9.83	8.69	11.33	3.54	.59	.38	7.03	15.98	.11	.0631	0	.0014	.0048	.0224	.0041	.0959
429	Subsoil	......	42.80	19.80	12.83	5.55	16.77	1.92	.24	.27	13.33	30.29	.05	.0597	0	.0051	.0099	.0202	.0054	.0876
430	Soil	G	46.82	12.36	12.94	9.57	3.89	3.86	.41	.15	1.34	3.05	.06	.0674	0	.0056	.0109	.0264	.0031	.0949
431	Subsoil	......	50.01	15.27	15.89	6.44	11.05	1.57	.34	.36	5.85	12.83	.05	.0458	0	.0051	.0033	.0172	.0038	.0909
	Yauco, Hacienda Santa Rita, Field No. 10:																			
432	Soil	C	46.74	24.60	10.28	5.13	10.02	1.95	.47	.23	6.84	15.54	.19	.0697	0	.0026	.0092	.0275	.0062	.1281
433	Subsoil	......	38.22	23.57	9.56	2.98	25.05	.41	.22	.17	17.15	39.07	.09	.0641	0	.0056	.0138	.0285	.0063	.1202
434	Soil	AG	59.13	13.18	8.23	11.47	2.00	5.13	.46	.15	Trace.	Trace.	.20	.0799	0	.0076	.0117	.0232	.0120	.1412
435	Subsoil	......	59.17	12.51	8.20	11.67	1.90	5.64	.36	.13	Trace.	Trace.	.11	.0687	0	.0057	.0108	.0162	.0106	.1242
	Yauco, Hacienda Florida:																			
452	Soil	G	24.81	32.27	8.54	4.34	28.78	.69	.42	.19	21.99	49.98	.09	.0789	0	.0072	.0143	.0358	.0051	.1326
453	Subsoil	......	9.48	39.16	4.07	1.06	45.53	.59	.33	.10	35.70	81.13	.03	.0569	0	.0097	.0106	.0292	.0057	.0635

[1] C, chlorotic; G, green; AG, always green, i. e., samples from fields which have never produced chlorotic cane.

There was no correspondence between the chlorosis of the cane and the percentage of any of the constituents determined in the acid or water extracts of the soils, although all soils producing chlorosis were strongly calcareous. While chlorotic cane was found only on markedly calcareous soils, all calcareous soils did not produce chlorotic cane. Cane, which for the time at least was green and vigorous, was found on a soil containing as much as 76.70 per cent[1] of carbonate of lime, and chlorotic cane was found on a soil containing as little as 13.23 per cent.

The three samples from fields where cane had never shown chlorosis contained only a trace of carbonate of lime. All soils in the southern part of the island where cane had never shown chlorosis were not examined, but doubtless many of them contain fairly high percentages of lime as carbonate. No consistent differences in regard to drainage or other physical features of the soils producing green and chlorotic cane were observable in the field.

From the preceding analyses it appears that this type of chlorosis of sugar cane occurs only on excessively calcareous soils but not on all such soils. This conclusion is justified by several years' subsequent observation.

EXAMINATION OF GREEN AND CHLOROTIC CANES FOR FUNGI.

The chlorotic and green canes growing where the samples were taken were examined in the field by J. R. Johnston[2] for evidences of disease. Pathogenic fungi were found on some but not all chlorotic cane, as well as on some green cane. On the whole, chlorotic canes did not seem to be attacked by fungi to any greater extent than were green canes.

ASH ANALYSES OF GREEN AND CHLOROTIC LEAVES.

As lime-induced chlorosis of pineapples was found to be associated in part at least with a lack of iron in the plant, analyses were made of comparative samples of green and chlorotic cane leaves for iron, lime, etc. The results are given in the table following.

---

[1] Green cane in this field yielded as high as 50 and 60 tons per acre.

[2] At that time pathologist of the Sugar Producers' Association of Porto Rico.

Ash analyses of green and chlorotic cane leaves.

Laboratory No.	Condition of leaves.	Carbon-free ash in dry substance.	Analyses of carbon-free ash.			
			Silica (SiO_2).	Lime (CaO).	Magnesia (MgO).	Iron (Fe_2O_3).
	B1753:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
455	Green	8.70	48.10	4.07	3.20	0.68
454	Chlorotic	9.17	38.01	3.85	3.34	.45
	Cristalina:					
707	Green	5.62	31.50	3.12	5.35	.153
708	Chlorotic	6.92	33.15	3.61	4.61	.124
709	Green	6.68	39.39	3.52	4.36	.160
710	Chlorotic	6.58	29.29	2.74	4.90	.130
	Otaheite:					
711	Green	5.45	40.21	4.77	3.45	.197
712	Chlorotic	7.02	37.69	3.85	3.79	.132
	Rayada and Otaheite, mixed:					
726	Green	7.87	45.61	8.64	5.50	.154
725	Slightly chlorotic	9.44	53.18	8.26	4.68	.144
724	Chlorotic	9.63	48.77	6.75	4.85	.163

Nos. 454 and 455 were the youngest fully formed leaves of B1753 cane, 8 months old, growing in soil No. 432 (table, p. 12). No. 455 was composed of green leaves from two stools previously made green by treatment with ferrous sulphate. No. 454 was from adjacent chlorotic stools.

Nos. 707 and 708 were, respectively, green and chlorotic new leaves from Cristalina cane, 9½ months old, growing within 10 feet of each other in soil No. 409 (table, p. 12). The canes had about 8 feet of stalk.

Nos. 709 and 710 were, respectively, green and chlorotic young leaves of the same age and kind of cane as Nos. 707 and 708 and were growing near the latter. They had only made about one-half the growth of Nos. 707 and 708.

Nos. 711 and 712 were, respectively, green and chlorotic new leaves from Otaheite canes, 13 months old, growing near each other in the field from which soils Nos. 420 and 422 were taken. The canes had about 10 feet of stalk.

Nos. 724, 725, and 726 were, respectively, chlorotic, slightly chlorotic, and green leaves of mixed Rayada and Otaheite cane, 3 months old, the chlorotic cane growing near where soil No. 432 was taken and the green cane near soil No. 434. Each sample was composed of the third youngest leaf from about 50 stools. Canes from which No. 726 was taken were much larger than those from which Nos. 724 and 725 were taken.

Where the comparative samples of green and chlorotic leaves were taken from canes of equal size growing in approximately the same soil (samples Nos. 455 to 712), the chlorotic sample had in each case a distinctly lower percentage of iron in the ash than the green sample. The percentage of the other constituents determined did not show any regular correspondence with the color of the cane. In the comparison between samples Nos. 724, 725, and 726, which were from canes of markedly different size growing on different soils, the chlorotic cane had very slightly more iron in the ash than the green cane.

If the last comparison were as valid as the first four comparisons the conclusion would be that the chlorosis is not connected with a lack of iron in the plant. In the light of subsequent work it appears probable that the comparison between samples Nos. 724–726 was not so fair as that afforded by the other samples. On this assumption the conclusion from the ash analyses is that the chlorosis is caused or accompanied by a lack of iron in the plant.

Considerable work was done with other plants because of apparent exceptions similar to that afforded by samples Nos. 724–726. As the details of this work have been published elsewhere they will not be fully discussed here. It is sufficient to note that in certain cases of extreme difference in growth it was found that plants lacking iron contained as high percentages of iron as plants well supplied with iron,[1] and that in other cases, where the development of the plants varied considerably, their percentages of iron did not reflect their need for iron at all stages of growth.[2] These exceptions are probably to be explained by the variation in the iron content of the whole plants at various stages of growth,[3] the marked difference in iron content of old and young leaves, and the probable immobility of iron in the plant after it has once been transported to the leaves.[4]

In view of the above facts it is believed that the comparisons afforded by samples Nos. 455–712 were fair, as they were made up of leaves of the same development from plants of equal growth,[5] and that possibly the comparison of samples Nos. 724–726 was not fair, as the leaves may have been of different age, the canes being of markedly different growth.

TREATMENT OF CHLOROTIC CANE WITH IRON AND STABLE MANURE.

As chlorotic pineapples were made green by brushing the leaves with ferrous sulphate, the same treatment was tried on sugar cane. In Haciendas Amelia and Santa Rita, two stools of cane with creamy white leaves in the midst of strongly affected areas were brushed three or four times with a 5 per cent solution of ferrous sulphate.

---

[1] Gile, P. L., and Carrero, J. O. Assimilation of iron by rice from certain nutrient solutions. U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 12, pp. 523, 524.

[2] Gile, P. L., and Ageton, C. N. The effect of strongly calcareous soils on the growth and ash composition of certain plants. Porto Rico Sta. Bul. 16 (1914), pp. 30, 31.

[3] Gile, P. L., and Carrero, J. O. Ash composition of upland rice at various stages of growth. U. S. Dept. Agr., Jour. Agr. Research, 5 (1915), No. 9, p. 357.

[4] Gile, P. L., and Carrero, J. O. Immobility of iron in the plant. U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 2, p. 83.

[5] It was, of course, possible to obtain green and chlorotic leaves from canes of equal growth only because these canes were alternately green and chlorotic during growth.

These stools soon became green, presenting a strong contrast to the surrounding chlorotic cane. The striking result of this test confirms the preceding evidence obtained from ash analyses and shows that the chlorosis is due in part at least to a lack of iron in the plant.

Although this treatment did not seem commercially feasible with pineapples, there was a possibility of its proving so with cane, since, as shown by the soil survey, cane is more resistant to lime-induced chlorosis than are pineapples.[1]

A field experiment was started at Central Cortada in 1911 on a quite uniform piece of chlorotic cane. The plats were one-twenty-fifth acre each and each different treatment was replicated on three scattered plats. The special treatments of the plats were as follows: (1) Checks, no special treatment; (2) ferrous sulphate applied to soil at rate of 100 pounds per acre; (3) stable manure with 5 per cent its weight of ferrous sulphate applied to soil at rate of 10 tons per acre; (4) stable manure applied to soil at rate of 10 tons per acre; (5) cane sprayed three times with a 5 per cent solution of ferrous sulphate at intervals of two months.

The field was planted with Cristalina cane in September, 1911, and the special additions were worked into the soil around the stools November 29, at which time the cane was markedly chlorotic. The first spraying was given January 10, 1912. Through an oversight the plats were cut in January, 1913, before the weights could be obtained, but the appearance during growth was as follows:

January 10, 1912, no concordant differences observable between plats; March 7, 1912, canes on plats receiving treatments Nos. 3 and 5 were larger and better colored than those on the remaining plats, which were all equally poor; May 9, 1912, plats receiving treatment No. 3 were best, those receiving No. 5 next, those receiving No. 4 next, those receiving Nos. 1 and 2 equally inferior to the preceding;

---

[1] Recently Johnson found in Hawaii (Hawaii Sta. Press Bul. 51 (1916)) that the chlorosis of pineapples occurring on manganese soils could be effectively overcome by spraying with ferrous sulphate. The treatment is a commercial success there, as only two to four sprayings to a crop are needed to maintain the green color and normal growth of the plants.

This discovery is not necessarily incompatible with the work at the Porto Rico Station on the lime-induced chlorosis of pineapples, rice, and sugar cane, in the course of which it appeared that so many sprayings were required to suppress the lime chlorosis as to make the treatment commercially unfeasible. It is true, however, that the work at the Porto Rico Station with rice and pineapples was on a very small scale. Possibly with more extensive trials or with variations in the method of application, the treatment might prove profitable for lime-induced chlorosis also, but such an assumption is not justifiable from the work already done.

It has been pointed out that lime-induced chlorosis is apparently due merely to a lack of iron in the plant caused by the fact that carbonate of lime depresses the availability of iron in the soil, and manganese chlorosis may be essentially the same, except that manganese rather than lime depresses the availability of the iron (Science, n. ser., 44 (1916), No. 1146, pp. 855–857). If this were so, it would not necessarily follow that the same *amount* of treatment would cure the two forms of chlorosis, since manganese and lime might depress the availability of iron to different extents.

August 15, 1912, plats receiving treatment No. 3 best, then No. 4, then No. 5, Nos. 1 and 2 both inferior; October 29, 1912, plats about the same as on August 15.

It is apparent that ferrous sulphate mixed with stable manure gave the best results, being superior to manure alone or to ferrous sulphate alone, which was no better than the check. So long as the plats receiving ferrous sulphate on the leaves could be sprayed these were among the best, but when this treatment had to be discontinued because of the size of the cane, these plats fell behind. It appears that, as in the case of pineapples, spraying with ferrous sulphate to be effective must be done frequently and continuously and is therefore not commercially feasible.

It was thought possible that dusting the leaves with powdered ferrous sulphate might prove more effective than spraying, as more iron could be applied at a time and with less labor. To test this point and to observe the effect of smaller amounts of stable manure, a second experiment was started in 1912. There were 20 plats of one-fourth acre each and four treatments, each different treatment being replicated on five scattered plats. The treatment and yield of plats are shown in the table given below. The mixtures of stable manure and ferrous sulphate, applied at the rate of 4 tons per acre, were worked into the furrow before planting. Cristalina cane was planted the middle of November, 1912, and cut January, 1914. The powdered ferrous sulphate was applied to the plants in April and June, 1913, each application being at the rate of 75 pounds per acre.

Effect of manure and ferrous sulphate on chlorotic cane.

Special treatment of plats.	Yield per acre of individual plats.					Average yield per acre.	Gain over checks per acre.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
No treatment, checks	36.2	22.1	29.2	23.0	32.0	28.5±1.8	....
Ferrous sulphate applied to leaves	34.5	19.8	24.3	28.0	41.8	29.7±2.6	1.4
Manure with 5 per cent ferrous sulphate	29.5	32.1	22.4	31.4	30.8	29.2±1.2	.7
Manure with 10 per cent ferrous sulphate	31.2	36.9	34.9	33.3	32.4	33.7±0.7	5.2

No marked concordant differences in the plats were noticeable during growth. Treatment with powdered ferrous sulphate not only did not appear to improve the color of the cane in the same way as spraying in the preceding experiment, but produced some injury where crystals lodged at the base of the leaf.

The yield of the replicated plats was quite variable, as was to be expected from the variations always to be seen in a field of chlorotic cane. The average yields, however, should be considered reliable, as the replicated plats were well scattered over the field. It appears that manure with 10 per cent ferrous sulphate was the only application producing a significant increase in yield. The increase, however, was not sufficiently large to make the treatment profitable when the price of sugar is low. The results serve to confirm observations made in the preceding experiment where no quantitative data were secured, but where differences appeared much larger with larger applications of the materials.

While the preceding experiments show that the chlorosis is ameliorated to some extent by the application of stable manure containing ferrous sulphate and stable manure alone, small applications of these materials produced very slight improvement and larger applications, though more effective, by no means overcame the chlorosis completely.

DISCUSSION OF RESULTS.

The preceding study shows that lime-induced chlorosis occurs only on calcareous soils, but not on all calcareous soils, and that it is probably caused by a lack of iron in the plant. The lack of iron in the plant is doubtless caused by the fact that the carbonate of lime depresses the availability of iron in the soil. It is evident, however, that in most soils the carbonate of lime does not depress the availability of iron below the amount needed by cane, although it does depress the availability below the amount needed by pineapples.[1] On those calcareous soils where chlorosis occurred, the availability of the iron must have been less than where chlorosis did not occur, but it was not evident just what conditions served to lower the availability.[2] The amount of organic matter in calcareous soils has been found to affect somewhat the amount of available iron in calcareous soils, and work, which is in the preliminary stage at present, seems to show that another factor is of marked influence.

This work on the chlorosis of sugar cane throws some light on the general subject of lime-induced chlorosis, since the data were obtained in the study of a plant that is relatively resistant to chlorosis. The ash analyses of green and chlorotic leaves show that the chlorotic leaves contained no more lime in the ash than the green leaves, and therefore increased assimilation of lime is probably not a contributory cause of chlorosis. This point was in doubt in previous work. The preceding data point to the existence of factors affecting the extent to which carbonate of lime depresses the availability of iron in the soil.

---

[1] This is shown by the fact that pineapples were found chlorotic on all calcareous soils (see Porto Rico Sta. Bul. 11 (1911)), and also by the work reported in Porto Rico Sta. Bul. 16 (1914), where pineapples and cane were grown on the same soils, the pineapples becoming chlorotic and the cane not.

[2] Evidently not alkaline salts. See table on page 12.

The method of supplying iron to the plants through the leaves was evidently effective, but was apparently not commercially feasible. The addition of organic matter, as stable manure, was beneficial, but obviously a great amount is required to produce a marked effect.

REPORT OF THE HORTICULTURIST.

By C. F. KINMAN.

SWEET POTATOES.

In December, 1916, seed material of 16 varieties of sweet potatoes was received from the Bureau of Plant Industry, United States Department of Agriculture. In the spring simultaneous plantings were made from these and from plants of the same varieties received from the same source in 1911, the latter having been in cultivation here for nearly six years. Fair yields were realized from all plats. The quantity and appearance of the potatoes produced from plants of one importation did not vary to any great extent from those of the others and all were markedly inferior in texture and flavor to those sent here from the North. The few roots which reached marketable size early in the season were superior in texture to the later ones. These, however, composed only a small part of the crop. The roots produced during the summer, when the soil is usually wet and when vines are making a rank growth, grow slowly and, with the exception of a few varieties, become hard before they are full sized and when cooked are dry and of poor flavor. The roots from late fall plantings which develop during the season of light rainfall are usually of better texture than the summer crop. It is planned to make plantings of the stock on hand and of another importation from the North to continue the testing of the apparent deterioration of northern types when grown in Porto Rico.

In further tests with Porto Rican types a variety locally known as Blanca has been found to produce roots which are superior to any of the lately introduced northern varieties both in texture and flavor. The vines of the Blanca make a vigorous growth and the yield of roots from station plats has been equal to the average of that from other varieties. When cooked, this sweet potato has a good moisture content, is tender, and is decidedly richer than the lately introduced kinds and probably more so than any common type grown here excepting the one known as mamey. The latter variety, which was mentioned in last year's report, is becoming well known in many localities of the island and its cultivation is rapidly increasing. While it is reported in many localites as producng somewhat lower yields than most other varieties, its production in Mayaguez this year has been only slightly below the average of other kinds. The vines are moderate growers, the roots smooth and medium sized, with light yellow skin and rich salmon-colored meat of first-class texture and flavor. This variety commands a considerably higher price than other kinds.

As it is the unvarying practice in Porto Rico to plant sweet potatoes by vine cuttings, the ordinarily low yields could probably be greatly increased by using plants taken from bedded roots at least once every two or three years.

COCONUTS.

In an experiment with coconut fertilization conducted for a number of years in a bearing grove, the number of nuts collected from the plats given a complete fertilizer fell off somewhat at the last harvest, as compared with the check plats, the fertilized plats not having made normal gains for several months. As the last application of fertilizer was given in June, 1916, it is possible that this falling off in yield results from the discontinuation of fertilization. It was not expected, however, that the fertilizer would cease to be effective at so early a date, as a much longer time intervened between the first application of fertilizer and the cessation of marked gains in yield of fertilized over unfertilized trees. The records of these plats will be taken for at least another year to determine the final result of the applications of fertilizers.

During the past year a survey of the coconut plantations of the island was inaugurated, and data have been collected regarding the number and size of nuts harvested in the respective groves, the soils planted to this crop, and the cultivation given, in an effort to determine the most profitable practices. As a coconut grove, if planted in suitable soil, will withstand prolonged neglect, many of the groves in Porto Rico are left entirely without care, and the annual production of this important food, as well as the grove owners' profits, are far below what might readily be obtained. Cultivation to eradicate grasses, break up sod, and stir the surface soil; and the planting of catch crops, as beans, peanuts, or similar plants, between the palms in young groves or in older groves where the palms are spaced so as to permit the entrance of sufficient light, will doubtless prove profitable in all sections. Animal manures, coconut husks, or any vegetable matter available should be spread over the grove and worked into the soil.

MANGOES.

During the last fruiting season seedling trees of several varieties of East Indian mangoes, including Cambodiana, Amini, Sandersha, Bulbulchasm, and Totafari, bore fruit, this being the second crop for the Sandersha seedlings but the first for all the others. Among these varieties, none except the Cambodiana bore fruit which resembled the parent variety at all closely either in external character, in flavor, or in color of flesh, and all except the Cambodiana had a high content of long, tough fiber, while the parent fruits were practically free from fiber. Trees from seeds of the variety known as Señora, sent from Cuba a few years ago, bore fruit this year of very inferior quality, although the parent fruit is considered as among the best flavored of the common Cuban types. The Señora trees have made a poor growth but have borne heavily. The seedling trees of the variety Cambodiana, grown from seed produced by grafted trees at the station, have made a very uniform and satisfactory growth, a large majority of them fruiting this year. The fruits from all except one tree were uniform in shape, quality, and flavor and were almost identical with the fruit of the parent trees.

The fruit of the one seedling which differs from the others has some of the qualities of the parent variety, but it resembles more closely the common Porto Rican type known as Blanco and appears to be a cross between the two kinds, showing none of the inferior quality and the deviation from the parent type and from the native shown by seedlings of the other varieties. This fruit is of medium size and has a rounded shoulder, smooth skin, and light yellow, juicy flesh of a melting consistency and a very rich, pleasant flavor, with a large, plump seed tapering to a rather pointed apex. In these points it is almost identical with the Cambodiana. It resembles the native types in that the apex of the fruit is full and rounded, the skin is a deeper reddish-yellow than the Cambodiana, the flesh has a slight turpentine flavor which is not sufficiently strong to be unpleasant, and the seed is thickly set with fiber which, however, is too short to be objectionable. This fruit is considered by some Porto Ricans to be superior in flavor to many of the imported mangoes, and it may prove to be of sufficiently high quality to warrant its dissemination through the island.

The fruiting seedlings indicate that for fruit production none of the varieties tested, except possibly the Cambodiana, is adapted to propagation by seed.

A survey made during the fruiting season this year showed that along the north side of the island and through the higher interior, where there is considerable rain during the blossoming season, the mango crop was small, as is usually the case in these sections. Through the western and southwestern sections, where the winter drought continues well into the spring, there was usually a good crop of fruit. This again points out the necessity of selecting a suitable location for planting if good crops of mangoes are to be secured.

CITRUS FRUITS.

During recent inspections through the citrus sections it was observed that the effect of the lack of fertilizer was already apparent on the trees of a few groves, and reduced crops of fruit will doubtless result unless balanced fertilizers are provided. All wood ashes which have been protected from moisture, as well as all tobacco stems, should be carefully saved for use as potash fertilizers. With these, aside from the applications of chemical fertilizers, which contain 2 or 3 per cent of potash, the grove can doubtless be maintained for a considerable time without marked deterioration. Planters who until recently made heavy applications of potash have been well repaid, as the potash remaining in the soil has nourished the trees so that for the most part they have continued to bear well. Fruit growers will make a great mistake if they are led to believe that the application of potash is not essential to productiveness or that heavy crops of fruit will not soon reduce the potash content of the soil to below the needs of the trees. That a fertilizer rich in potash is needed by citrus trees through the sections of Porto Rico where this fruit is chiefly grown has been well established by experiments.

MISCELLANEOUS INTRODUCTIONS.

Among the large number of introduced plants being tested at the station the following, not previously mentioned, have shown sufficient promise during the past year to be worthy of special note:

Crotalaria saltiana.—Plate II, figure 1, shows a small plat of one-year-old plants of this species growing on a low, heavy soil which, while fairly fertile, is water soaked during the summer months and becomes very hard and dry through at least a few inches from the surface during the dry winter and spring. This photograph, taken April, 1917, near the end of the dry season, shows the heavy vegetation and large seed crop produced, proving the ability of this plant to succeed during both dry and wet seasons. It has been tested in other soil types with good results, has resisted unfavorable weather conditions better than any other of the large number of legumes tested here for temporary crops, and will no doubt prove especially valuable for reclaiming barren hillsides or badly worn or washed soil and for furnishing temporary wind protection for other crops. The plants are very prolific, with a ripening season for the seed extending over a long period.

Tabebuia spectabilis.—Small specimens sent to the station about 8 years ago have made a steady though slow growth and are now slender trees 6 inches in trunk diameter and 30 feet tall, with a comparatively broad spread of branches. While the growth has been too slow to warrant planting for production of the valuable lumber, which is said to be very hard and durable, this species is of exceptional value as a flowering ornamental. The flowers, growing in large bunches often 6 or 8 inches in diameter at the end of each branch, are of a rich yellow color, and as they often appear after the leaves have fallen, the tree presents a very striking appearance and is probably not excelled in beauty and attractiveness by any other tree in the island. At Mayaguez the blossoms appear in April and remain open a few days.

Corypha sp.—One of these palms planted at the station about 11 years ago made a slow growth for some time, but has been developing rapidly for the past 3 or 4 years. The tips of the leaves reach 36 feet in height and have a spread of 50 feet. The leaf petioles, the margins of which are thickly set with long, sharp spines, are 22 feet long and the leaf is 14 feet in its broadest diameter. The ruggedness and grace of this palm give it a peculiar attractiveness and make it exceedingly valuable for landscape gardening. (Pl. III, fig. 1.)

Plants of the East India sugar palm (*Saguerus saccharifer*) which were planted about the same time as the *Corypha* sp. have proved suitable for ornamental planting in Porto Rico, especially for avenues where they are protected to some extent from the wind. Seed which are now more than two years from the blossom will soon be sufficiently mature for planting and the young palms will be distributed through the island.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

Within the past year two publications embodying the results of work with coffee have been issued as bulletins of the station. The first[1] dealt with the unsuitability of the upper slopes of many hills now planted to coffee in contrast with the suitability of the lower slopes of the same hills. The second[2] showed the large increase in early yield and development of the coffee tree to be had as a result of removing the seedling from the nursery with its roots in a large clod of earth rather than transplanting with the root system free of earth.

In the coffee plantations at the higher altitudes where climatic conditions are much more favorable for the growth of coffee than nearer the coast, a very serious leaf disease, *Stilbella flavida*, has done extensive damage in many places, so debilitating the tree through long continued defoliation that the crop is greatly reduced and the plantation made unprofitable. On one such plantation,

---

[1] Porto Rico Sta. Bul. 21 (1917).
[2] Porto Rico Sta. Bul. 22 (1917).

FIG. 1.—CROTALARIA SALTIANA, A GREEN-MANURING CROP.

FIG. 2.—FERTILIZER EXPERIMENTS WITH COFFEE. COMPLETE FERTILIZER AND MANURE ON LEFT, CHECK ON RIGHT.

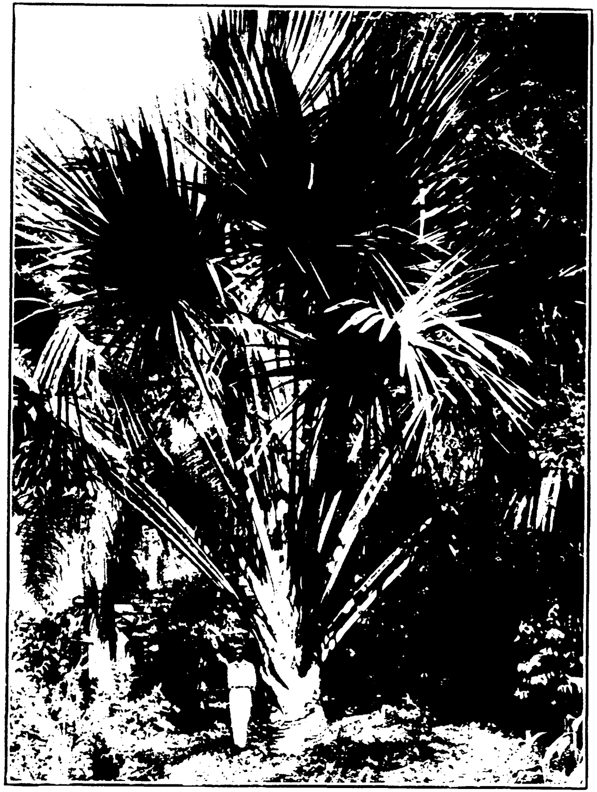

FIG. 1.—CORYPHA SP., AN INTRODUCED PALM.

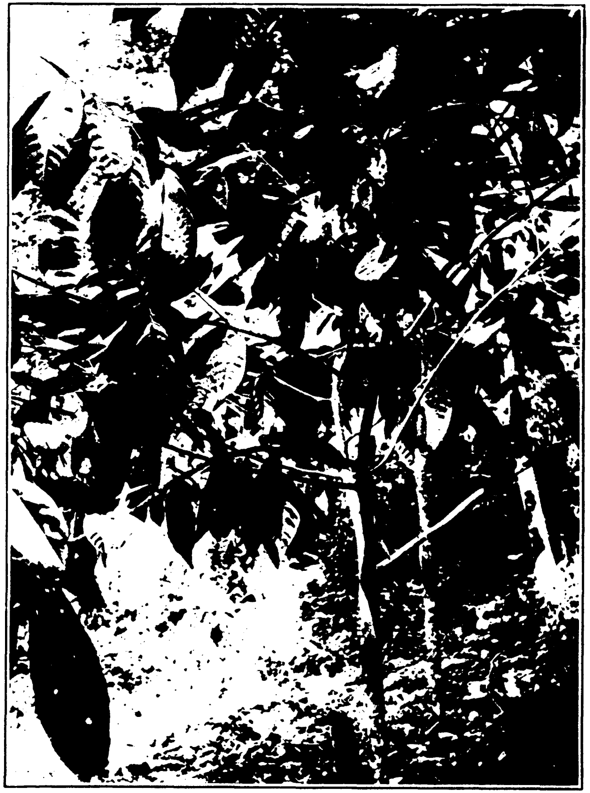

FIG. 2.—RED CRILLO CACAO TREE 5 YEARS FROM SEED.

in an almost abandoned state, this department, in cooperation with other departments of the station, has begun an experiment in restoring the coffee to a productive and profitable condition. In the plat selected, of about 1½ acres in extent, the coffee trees were cut at 6 to 12 inches above the ground and their foliage burnt or removed. As numerous weeds are also host plants for this fungus, the ground was cleaned of weed growth, and clean cultivation will be practiced as far as possible. Bananas were planted around the edge of the plat to aid in intercepting the passage of fungus spores from without. At a little more than 6 months after cutting the coffee, the plat appeared to be in excellent condition with new growth 1 to 3 feet in height from the old coffee stumps. No sign of Stilbella was seen, though more than 500 trees were examined.

Different species of introduced coffee have been set in patches of *Coffea arabica* affected with Stilbella in an attempt to find a resistant species.

In continuance of the work with Murta coffee mentioned in the last year's report, 700 seeds were planted from blossoms which had been protected from foreign pollen. Of these, 272 failed to germinate or died before they could be classified. Of the remainder 56.1 per cent were classified as Murta type, 25.7 per cent as the dwarf rosette type, and 18.2 per cent as the ordinary Arabian type. These proportions indicate inheritance of the Murta form along Mendelian lines.

The very short internodes of Murta coffee allow the production of a large number of cherries on a short length of branch. The grains are similar in size and appearance to the typical Arabian coffee, but the tree is slightly later in coming into bearing. The trees are small and the yield per tree through the sixth year has not been large. Indications are that to make this variety profitable two or three times as many trees should be set per acre as of the typical Arabian coffee.

In a fertilizer experiment with 40 plats of 3 young coffee trees each, the first crop at three years from seed showed a large increase in yield from the plats which had received nitrogen, when the results were grouped according to whether the trees had or had not received nitrogen either singly or in combination, the 20 plats not receiving it constituting the check. Of the 12 plats which gave the highest production nitrogen had been used in the fertilizer applied to 10 of them.

In a test with older trees, in which applications of a complete chemical fertilizer and stable manure have been made twice annually for a number of years, the fertilized plat produced this past season 73.4 per cent more than the check. (Pl. II, fig. 2.) The preceding season their yields were nearly uniform, however, the mean of the yields for the two years giving about the usual proportional increase for fertilizer in this planting.

In a lime and nitrogen test with coffee trees grown for two years in 5-gallon cans, the 18 plants grown in the limed soil differed from the 3 check plants in average weight by only a very small fraction of 1 per cent. These had received lime in a series of amounts ranging in rate from ½ ton to 16 tons per acre, the rate being doubled for each group of three trees. From the lightest application the weight of trees averaged 2.4 per cent greater than the check, from the heaviest application 0.2 per cent greater. A few cherries were produced, the average yield from the limed trees being identical with the check. In the division which had received nitrogen there had been made at intervals of six months three applications of 8 grams each per tree of ammonium sulphate to one group and to the others sodium nitrate ranging in amount from 4 to 16 grams per tree per application. The weight of the trees fertilized with ammonium sulphate averaged 22.1 per cent greater than the check; those which had received sodium nitrate averaged 22.9 per cent greater than the check. The trees which had received 4, 8, and 10 grams of sodium nitrate fell below, while those which had received 12 and 16 grams of sodium nitrate surpassed, those which had received 8 grams of ammonium sulphate, 16 grams of sodium nitrate producing an increased weight of 50.3 per cent over the check. The production of cherries averaged 87 per cent greater for the fertilized trees than for the check.

Distribution of seed of promising coffee varieties was continued as in former years.

CACAO.

The work with *Vanilla planifolia* is requiring an increasing to the product of individual trees. (Pl. III, fig. 2.) From the older orchard set in 1903, the yield for the calendar year 1916 exceeded that of any preceding year, though more than one-fifth of the trees produced nothing. (Pl. IV, fig. 1.) The others averaged 20.7 pods per tree. More than half of the crop matured in April, May, and June. Rats have become exceedingly destructive in this planting, at times destroying as much as 75 per cent of the crop and even eating out pods before they have begun to change color. The low form to which the tree should be kept for picking, the fruiting habit of the tree, and the inclination of the land all combine to make it impracticable to keep rats out. For many weeks poisoned pods were placed in the planting twice weekly, but this proved entirely ineffectual in controlling the rats, as pods were continually ripening on the trees and furnishing a constant and abundant supply of fresh food.

VANILLA.

The work with *Vanilla planifolia* is requiring an increasing amount of time and attention. The personal factor in the handling of vines and crop plays so large a part that it is a very interesting field for investigation.

In a planting test with 48 tip cuttings of 10 nodes each half were left to wilt in a fairly well-shaded place for an interval of 12 days between cutting and planting, the others being set immediately. Half were planted in a mixture of equal parts clay and river sand and half in leaf mold. Two months after the first were planted half the vines were removed, the others being left 12 days longer. Root growth was measured on removal. These measurements showed the root development to have been 85 per cent greater in leaf mold than in soil, while the new vine growth was also considerably greater. Cuttings which had been wilted for 12 days before planting in root development at two months after cutting fell far behind those which had been planted immediately, but when the cuttings which had been wilted 12 days prior to planting were measured 12 days later than those cut simultaneously but set immediately, it was seen that the root development of vines planted for an equal period was greater for the wilted cuttings. As growth under both treatments was vigorous and highly satisfactory, the planter's convenience should determine whether vanilla cuttings are to be set immediately or left for some days before planting.

Vine growth was marked to determine what maturity was necessary for flowering. Blossoms opened in the spring on vine growth of as late as the preceding midautumn. This shows the importance for the following crop of keeping the vine in vigorous growth through the cropping season and not allowing the full strength to go into the crop being produced.

A period of approximately two months was observed to elapse between the pushing out of the inflorescence bud and the opening of the first blossom. After blossoming the pods attained full length in six to eight weeks, though seven to nine months were required for maturing.

Vanilla blossoms open only once and that in the morning, beginning to close in the early afternoon. Fertilization ensued from pollinations made at various hours throughout the day from before daybreak until after nightfall. Fruit set from more than 90 per cent of the hand-pollinated blossoms in a recorded series and from 1½ per cent of a series not hand-pollinated. No reason was found for the failure of some pollinations to cause fertilization. Working steadily, the writer pollinated in one hour 237 blossoms. This rate did not afford time for the proper selection of blossoms but demonstrated that hand-pollination need not be costly on account of the time requisite for the operation itself.

In curing small quantities, blistering was found to result from sweating the pods between scalding and drying, sometimes 20 to 50 per cent of the pods developing watery blisters. The omission of this sweating reduced the proportion of blistered pods to less than 2 per cent, but an extract expert reported the quality of the unsweated pods as inferior to that of the sweated pods. As the quantities available were too small to retain heat in sweating, the result secured at the station refers only to curing small quantities.

The yield from a small planting of 4-year-old vines averaged slightly more than half a pound of cured beans per vine. Samples were sent to dealers and extract manufacturers and were very favorably reported, indicating a ready market for such vanilla at from $3 to $4 a pound.

REPORT OF THE PLANT PATHOLOGIST.

By H. E. THOMAS.

The work of this department during the year was principally with vegetable, vanilla, and citrus diseases. Some time was given to minor diseases of other crops.

VEGETABLE DISEASES.

A wilt disease of beans caused by an undetermined Phycomycete was abundant during the past rainy season. The fungus spreads from the soil to the adjacent leaves, stems, and pods as a vigorous, fluffy white growth which often kills the entire plant in an incredibly short time. Considerable increase in this disease was noted in poorly drained situations. Of 19 varieties tested during a single season, only two, Black Venezuelan and White Marrow, showed any marked resistance to the parasite, the Black Venezuelan variety seeming quite highly resistant.

A rust of Lima beans apparently not previously reported was abundant in the station gardens from April to June, 1917, on Burpee's Bush Lima. It has also been observed near Adjuntas on a type of Lima bean locally called Habas Mayorca. The causative fungus was identified by J. C. Arthur as *Uredo concors*. Considerable damage may be caused by this fungus in the direct destruction of leaf surface and in providing points of infection for weaker parasites, particularly *Isariopsis griseola*.

Powdery mildew (*Erysiphe polygoni?*) was very abundant during the winter months on kidney beans and some minor vegetable crops. Dusting with equal parts of lime and flowers of sulphur easily controlled this fungus.

Cabbage plants at Lares were affected by a virulent form of a disease indistinguishable from the ordinary black rot. The causative organism in culture is similar to *Pseudomonas campestris*. While the black rot has not been definitely reported from Porto Rico, there seems little doubt that the disease found here is identical with that known in continental America.

Tomatoes at Mayaguez were badly affected by downy mildew (*Phytophthora infestans*) during the cool months of the year, while those planted in the same garden as warm weather approached were practically free from this disease. The leaf mold caused by *Cladosporium fulvum* was severe on tomatoes planted after the rainy season began. Four applications of Bordeaux mixture from April to June checked the disease considerably but did not satisfactorily control it. Plants dusted at the time of the above applications with a mixture of equal parts lime and flowers of sulphur showed as much disease as the controls. A single instance of bacterial wilt has come to notice from Bayamón, the causative organism of which in culture closely resembles the description of *Bacillus solanacearum.*

Other vegetable diseases of less economic importance noted during the year are: Leaf spot of beet (*Cercospora beticola*), downy mildew of melons (*Plasmopara cubensis*), leaf spot of okra (*Cercospora hibisci*), leaf spot of peanut (*Cercospora personata*), downy mildew of potato (*Phytophthora infestans*), and bean leaf spots (*Cercospora cruenta* and *Isariopsis griseola*).

VANILLA DISEASES.

Considerable spotting of vanilla leaves has been found on older plants in moist situations. The common leaf spotting alga (*Mycoidea parasitica*) seems to be the principal organism involved. Young and vigorous plants are not seriously affected by this disease. *Glœosporium rufomaculans* has appeared occasionally on vanilla, causing defoliation and sometimes death of the entire plant. Pruning off the affected part did not prove beneficial after the disease had made any considerable progress. In such case, it is better to replace the plants by vigorous cuttings. By removing diseased material and stimulating the vigor of the plant, this trouble has been reduced to a minimum.

Vanilla plants at the station are affected by a disease of the roots which does not seem to have been described. The underground roots and the aerial roots from 1 to 2 feet aboveground are destroyed and fruiting of affected plants is greatly reduced or is entirely prevented. A species of Fusarium has been repeatedly isolated from the margin of diseased tissue. Infection and control experiments are under way.

CITRUS DISEASES.

The withertip fungus (*Colletotrichum glœosporioides*) has been quite active during the past year, partly because of lowered vitality in the trees from lack of fertilizer. A few cases have been noted in which the initial injury results from poor drainage, impervious subsoil, or use of sprays. The damage done by this fungus to vigorously growing trees is very slight.

Citrus scab (*Cladosporium citri*) caused considerable losses during the past season, although dry weather in May prevented the usual heavy infection. Experiments in the control of this disease were begun in February, 1917, by L. R. Hesler, of Cornell University, and were carried through the latter part of the season in cooperation with this department. These experiments will be reported upon separately.

The following diseases of cereals have been observed in small amounts: Leaf spot of field corn and sweet corn due to *Helminthosporium inconspicuum*, blast of rice (*Piricularia oryzæ*), wilt of wheat (*Sclerotium rolfsii*).

PROGRESS REPORT ON CITRUS SCAB.

By L. R. Hesler.

Citrus scab continues to prove detrimental to the production of clean grapefruit. Preliminary work started in February, 1917, was carried forward by the writer to April 30 of that year. It was subsequently taken over by the assistant plant pathologist, to whom much credit is due for ably prosecuting the investigation. Most of the writer's time was devoted to a study of the cause and control of the trouble.

Microscopic and cultural studies support the contention that scab is caused by a parasitic fungus, as has been found in Florida.[1] The organism is referred to in literature as *Cladosporium citri.* Observations indicate that several factors are concerned in the amount of scab. Meterological conditions not only affect the fungus but also exert an influence on the growth of the grapefruit, tending to increase its susceptibility. Likewise the use of fertilizers induces rapid succulent growth of the host and hence increases its sensitiveness to scab.

Preliminary spraying and dusting experiments were conducted in two different groves on the island. The following materials were used: Bordeaux mixture; lime-sulphur 1:30 (commercial solution); soluble sulphur, 3 pounds to 100 gallons water; sulphur dust (finely ground flour); and soluble sulphur dust with various diluents as lime, sulphur flour, cornstarch, and talc. The applications, varying in number from two to seven, were made in March, April, May, and June. The question of the number and frequency of applications needs further attention. Several trees were also left untreated as checks. In general, Bordeaux mixture was more efficient in the control of scab, but it also destroyed the scale parasitic fungi. The sulphur fungicides were less effective for scab control but also less injurious to the scale parasites. It is the writer's opinion that several applications of a standard liquid sulphur fungicide, such as lime-sulphur solution, applied for the control of both scab and scale, supplemented by occasional spraying with Bordeaux mixture for scab, will be worth thorough trial in commercial groves. The number of applications will be variable, depending on the rapidity with which new growth is uncovered and on the severity of the case in hand. The scab problem deserves more intensive investigation.

---

[1] Fawcett, H. S. Citrus scab. Florida Sta. Bul. 109 (1912), pp. 51–59; Phytopathology, 6 (1916), No. 6, pp. 442–445.

REPORT OF THE ENTOMOLOGIST.

By R. H. VAN ZWALUWENBURG.

THE CATTLE TICK.

The life history study of the Australian cattle tick has been continued. A complete understanding of the various nonparasitic stages of the tick is necessary to successful starvation of the pest by pasture rotation. The accompanying tables show some results of the work.

The insectary rearings were made in a weather shelter of the standard Weather Bureau type. The outdoor rearings were made in concrete drain tiles set in the earth with a few inches of the tile above the surface of the soil. Weeds and grass were allowed to spring up inside the tile, which was filled with soil to the level of the earth outside. A cylinder of galvanized netting closed at the upper end was set over the tile, affording an eminence for the seed ticks to congregate upon.

The quickest and most certain way to exterminate the tick is, of course, by a wholesale and consistent dipping program. The starvation method is not practicable in case of work cattle subjected to reinfestation along any road they travel nor in cases where only limited pasturage is available. A campaign of tick eradication in Porto Rico will, as in the States, have to depend primarily upon dipping, with starvation as a supplementary measure. Dipping kills all ticks brought on the cattle to the vats, while starvation of ticks prevents the dipped cattle from being reinfested.

A dipping vat has been installed at the station and all cattle on the estate are being dipped regularly every two weeks in a bath containing 0.19 per cent arsenious oxid, the standard low-strength solution. The minimum time for parasitic development of ticks on a heifer is 20 days in October. Dipping every two weeks allows for any lessening of this minimum during warmer seasons of the year and has the advantage of regularity. Cattle dipped every two weeks are in no way injured; even the milk flow of the dairy cows is not noticeably lessened.

One hundred and thirty engorged ticks were passed through a dip containing 0.16 per cent arsenious oxid. Only 30 (23 per cent) died without laying, showing that such strength is not effective against adult females.

Preoviposition period of female ticks kept in closed tins in weather shelter compared with same period under natural conditions.

Month.	Weather shelter.					Natural conditions.				
	Preoviposition period.			Number of females in series.	Average mean temperature.	Preoviposition period.			Number of females in series.	Average mean temperature.
	Average.	Minimum.	Maximum.			Average.	Minimum.	Maximum.		
1916.	*Hours.*	*Hours.*	*Hours.*		°F.	*Hours.*	*Hours.*	*Hours.*		°F.
September	85.9	65.0	113.0	20	80	84.4	65.5	95.3	11	80
October	90.5	77.5	117.5	10	80	82.4	72.0	91.0	19	80
November	109.8	79.5	179.5	10	79	95.8	87.3	106.5	18	79
December	111.7	87.5	136.5	10	76	......	......	......	......	......
1917.										
January	150.4	122.7	231.7	10	72	......	......	......	......	......
February	146.3	118.5	219.0	10	71	......	......	......	......	......
March	138.8	119.8	167.8	18	73	......	......	......	......	......
April	110.3	75.5	126.0	8	74	......	......	......	......	......
May	114.5	95.3	136.3	10	76	......	......	......	......	......
June	95.6	74.3	122.0	19	77	......	......	......	......	......
July	94.8	77.5	124.2	16	79	......	......	......	......	......
August	100.8	81.0	129.5	20	78	......	......	......	......	......

Egg-laying period of female ticks kept in closed tins in weather shelter compared with same period under natural conditions.

Month.	Weather shelter.				Natural conditions.			
	Egg-laying period.		Number of females in series.	Average mean temperature.	Egg-laying period.		Number of females in series.	Average mean temperature.
	Average.	Maximum.			Average.	Maximum.		
1916.	*Days.*	*Days.*		°F.	*Days.*	*Days.*		°F.
September	13.8	19	32	80	12.3	14	12	80
October	13.5	17	10	79	......	......	......	......
November	17.0	20	10	77	......	......	......	......
December	14.9	18	10	74	......	......	......	......
1917.								
January	16.6	20	10	74	......	......	......	......
February	13.4	16	10	73	......	......	......	......
March	13.8	24	19	72	......	......	......	......
May	9.9	14	10	79	......	......	......	......
June	11.3	15	8	79	......	......	......	......
July	11.9	17	8	80	......	......	......	......
August	14.4	18	10	79	......	......	......	......

Incubation period of tick eggs in weather shelter compared with same period under natural conditions.

Month.	Weather shelter.					Natural conditions.				
	Incubation period.			Number of lots in series.	Average mean temperature.	Incubation period.			Number of lots in series.	Average mean temperature.
	Average.	Minimum.	Maximum.			Average.	Minimum.	Maximum.		
1916.	*Days.*	*Days.*	*Days.*		°*F.*	*Days.*	*Days.*	*Days.*		°*F.*
September	29.7	28	32	32	80	26.7	23.0	30	6	80
October	29.6	27	32	22	79	26.6	25.0	29	8	79
November	31.0	30	33	11	76	30.1	29.0	32	6	76
December	......	......	......	......	......	33.3	30.5	44	8	73
1917										
January	39.0	38	40	2	73	34.0	28.0	42	8	73
February	37.9	35	41	9	72	......	......	......	......	......
March	34.6	32	36	8	73	......	......	......	......	......
April	28.6	27	32	11	76	......	......	......	......	......
May	28.4	27	31	7	78	......	......	......	......	......
June	28.6	26	31	7	79	......	......	......	......	......
July	26.5	25	29	13	79	......	......	......	......	......
August	26.4	24	30	12	78	......	......	......	......	......

A NEW CORN PEST.

It is a very common thing in Porto Rico for a large percentage of ears in a corn planting to fail to set kernels. This is apparently due principally to the work of the larvæ of an undetermined phorid fly, which was first noted during the past year. While work was under way against the corn ear worm and fall army worm, it became evident that those two pests were in that particular instance of minor importance as compared with the "corn-silk" fly.

The slender white eggs are laid in clusters of 25 or more among the strands of the new silk, several egg clusters often being placed in the tuft of a single ear. The larvæ upon emerging from the egg feed on the silk strands, following them downward. Often practically all of the strands will be destroyed in this manner before the silk has been pollinated, and as a result almost no kernels will set. The work of the larvæ also attracts scavenger beetles such as Carpophilus and no doubt paves the way for fungus infection. In June over 75 per cent of the ears in a field at the station were found either infested with larvæ or with eggs in the silk tuft.

Bagging several ears as soon as eggs were found established the fact that the fly is a primary pest and not a scavenger. A capsid bug was found in some numbers apparently feeding upon the eggs of the fly. Observations upon the corn-silk fly are being continued.

MISCELLANEOUS.

The striking black and white larvæ of the noctuid moth *Noropsis hieroglyphica* feed commonly on the foliage of *Waltheria americana* and have also been reared upon *Morongia leptoclada*. The larvæ are more or less gregarious and drop to the ground when disturbed. The full grown larva is about 25 millimeters long and about 4 millimeters across the head. The ground color of the body is bluish or greenish white with a black stripe running around the body on each segment. The segments are divided one from another by a narrow black line. The anal plate and head are reddish brown, the collar shiny black. The oval pupa case, about 22 by 10 millimeters, is formed of parchment-like material on the stem of the food plant and is covered by grass and bits of leaves.

A heavy infestation of *Anastrepha fraterculus*, the mango fruit-fly, was observed near Maricao in July in poma rosa fruits (*Eugenia jambos*). This is the first record of this plant as a host of the fly in Porto Rico.

Among the very few insects observed upon vanilla, a promising new crop for the island, was the scale *Conchaspis angræci*, which is not likely to become important.

In June there was a general outbreak in the vicinity of Mayaguez of the noctuid *Melipotis januaris* on guamá (*Inga laurina*). On the morning of June 7, thousands of the larvæ were to be seen suspended from the trees; by noon they had practically all regained the leaves. After four days hardly a larva was to be found, the greater part having entered the ground to pupate.

The experiment with lime and salt as repellents against *Strategus quadrifoveatus*, a rhinoceros beetle attacking the coconut, has so far been negative, for no beetles have appeared in the planting. It seems generally true that a surrounding growth of cane, pigeon pea, or similar crop during the rainy season affords some protection from the beetle.

Experiments to determine the value of cyanamid as a remedy for white grubs in cane soil show that heavy applications of cyanamid alone (up to 2 pounds to the stool) have no effect on even second instar grubs. Mixtures of cyanamid with other chemical fertilizers are being tested.

Serious attacks by the slug, or "lapa" (*Veronicella occidentalis*), have been observed on beans and tobacco. Clearing up the breeding places is recommended, as well as trapping the slugs under boards smeared on the side next the ground with attractive substances such as rancid fats.

The trapping of changas at a light has been continued. To date 58 per cent of the catch has been females.

REPORT OF THE ASSISTANT IN PLANT BREEDING.

By W. P. SNYDER.

The writer was appointed a member of the station staff in April, 1917. The work to date has consisted mainly of testing introduced varieties of wheat and oats and of making selections for the improvement of varieties of the more important vegetables. It is planned to try out a number of varieties which have not been previously grown at the station, in order to select the more promising ones as a basis for future breeding.

A record was kept of the yields of 52 varieties of Indian wheats and of two varieties of oats known as Swedish Crown and Swedish victory. Seed had been obtained from the Office of Cereal Investigations, of the Bureau of Plant Industry, U. S. Department of Agriculture, and planted in trial rows on February 16 and 19. These dates were found to be too late for good results, as the harvest for the wheat varieties, from May 13 to June 6, was caught by the heavy rains which began on May 22, and the majority of the crop was ruined. The crop of oats was almost totally destroyed, but a few ripe heads were obtained on July 23. The yield of the wheat varieties varied widely, ranging from nothing to the equivalent of 30.8 bushels of grain and 4,629 pounds of straw to the acre for the variety designated as C. I. No. 4558, which was one of the six varieties to mature before the rains set in. Selections were made of the highest yielding plants of a number of the varieties, and in November a second sowing will be made. This will permit a fair comparison of all varieties, as the harvest will thus come in the dry season.

A number of different varieties of beans were planted in April, and selections were made of the highest yielding plants at the time of the harvest in July. Subsequent selections were made from other plantings on the station grounds, and a second generation is now being grown in the hills near Mayaguez, where the facilities for drainage are such that the heavy rains are not particularly injurious. A small planting was also made on the low ground near the station with the view of developing a strain resistant to a soil Phycomycete which is very injurious in wet weather. At present, a black Venezuelan bean seems to be decidedly the most productive of all varieties tested at the station.

Selections have also been made of okra, Chinese mustard, sweet potatoes, and a white sweet corn from Venezuela. It is planned to make a number of crosses between this Venezuelan corn and several of the best sweet-corn varieties from the States which are not productive in Porto Rico.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. Henricksen.

The author took up the demonstration work October 4, 1916. On account of the fact that most of the plantings of fruits have been made on the northern side of the island, headquarters were established in the Federal Building at San Juan. Two lines of work were planned, one to include the fruit district from Trujillo Alto to Arecibo, comprising that part of the coastal plain not planted to sugar cane; the other to deal with the lower hill district planted chiefly to food crops by small farmers. Getting in touch with the fruit growers offered no difficulties, as nearly all of them were familiar with the station and its work, and the first three months were devoted entirely to visits of inspection to their plantations.

The fruit industry comprising citrus fruits and pineapples is largely in the hands of individuals and in companies organized in the States. The enterprises are mostly financed in the States and the managers are, as a rule, progressive. There are few who are not willing to cooperate in experimental or demonstration work, and it is not unusual to find men who are conducting more or less elaborate experiments without assistance. On that account, a great deal of information has accumulated which needs to be brought together, sifted, and compiled. An outline of such work was drawn up and a beginning made by reorganizing the Horticultural Society, but the undertaking got no further than the initial stage because of pressure of other work. The work of coordinating data based on local experience should be finished before further experimental work is undertaken, as by use of these data many minor problems which might demand experimental attention will be eliminated and the outstanding problems can be attacked intelligently.

The other line of work mentioned above, that in the lower hill districts where food crops are produced on small patches of ground, was inaugurated during the early part of the year in connection with the emergency work of the Food Commission. This is a work of such great magnitude that one or two men could not attempt to cover the whole field, but fortunately cooperation with the department of education is possible. During the last few years that department has been paving the way for agricultural extension work through the rural schools, the whole staff, from the commissioner of education to the teachers in the rural districts, being intensely interested in agricultural development, especially among the small farmers. Acquaintance with the teaching staff and with the school work was gained during the winter by attending teachers' conferences held in the different school districts and so-called parents' meetings held usually on Sundays in the outlying districts. Mimeographed

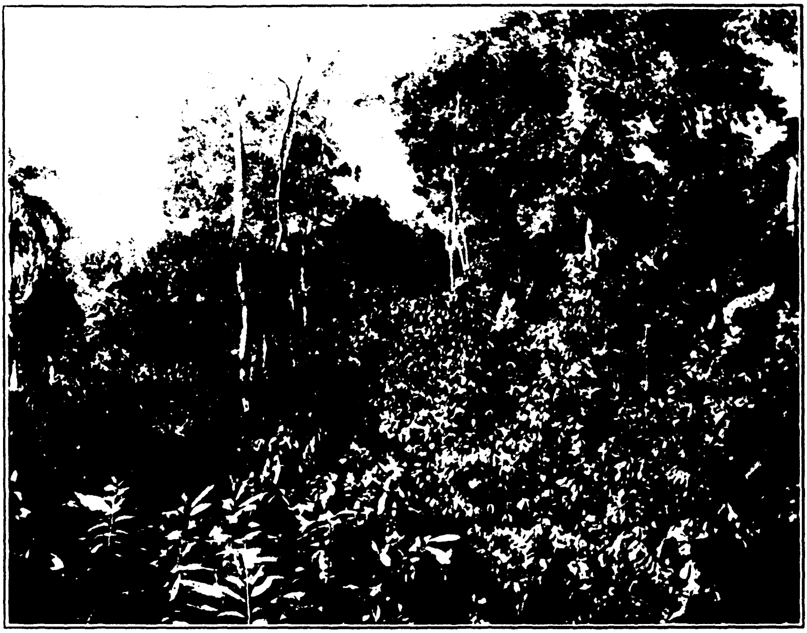

FIG. 1.—CACAO PLANTATION.

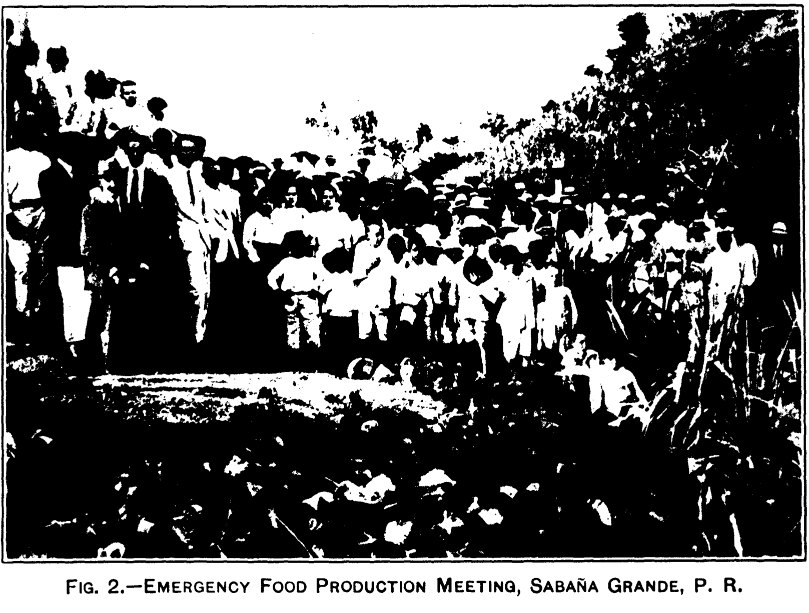

FIG. 2.—EMERGENCY FOOD PRODUCTION MEETING, SABAÑA GRANDE, P. R.

circulars, lectures, charts, etc., were furnished to a number of teachers for these meetings and some lectures with lantern slides were given. Plans were outlined for continuing the work along these lines, which, by the month of May, were well under way.

At that time, the work as outlined was greatly extended by the appointment of a food commission by the governor, the writer being appointed a member of the subcommittee on agriculture and given entire charge of the agricultural field work undertaken by the commission. This food commission was created by a joint resolution of the legislative assembly and given an appropriation of $1,000,000, out of which a certain amount was set aside by the commission for agricultural field work, an organization being formed which by the end of the fiscal year numbered 44 men, all former or present employees of the department of education familiar with the districts in which they were appointed and with agricultural work, although they were by no means agricultural experts. However, expert knowledge was not required, the small farmer of Porto Rico not having reached the stage where he can utilize such knowledge. He needs to be told the rudimentary facts and to have demonstrated the simpler improved methods.

The agricultural agents went from farm to farm, urging people to plant food crops, telling them what to plant and how to do it in a manner to insure better yields, trying to induce the large landowners to let poor people plant idle land on shares, and urging idle people to go to work and plant. Meetings were held in towns and villages and in the schoolhouses in the most remote mountain districts, committees were appointed and associations were formed in all parts of the island, so that in a few months the interest created was far beyond expectation. (Pl. IV, fig. 2.)

At the beginning of the school year (Sept. 1, 1917), the service was entirely reorganized. Twenty-five men, most of whom were graduates of the Porto Rico Agricultural College or other agricultural schools, were engaged by this department and paid by the food commission. A scheme was perfected for cooperating with the department of education by which the agricultural teachers became partly responsible to the station and all rural teachers became collaborators, while the 25 men paid by the food commission became district agricultural inspectors partly responsible to the district school supervisors. This arrangement is very satisfactory to all concerned and through this cooperation both departments have been enabled to do more efficient work.

Among the lines of regular work now under way, the following are of greatest importance:

The first general crop statistics collected in Porto Rico were finished in August and the data obtained show the acreage of food crops, the work being continued through weekly reports, and all other crops, as well as live stock, being reported upon twice per year.

Committees are being formed in all districts and it is hoped that before the end of the school year there will be an agricultural committee in practically every barrio in the islands.

The "parents' meetings" of the educational department having largely developed into agricultural meetings, this office is sending out thousands of copies of lectures, circulars, charts, Farmers' Bulletins, and other educational matter for their use.

Certainly the experiment station has been brought to the farmer in Porto Rico, as there is not a district where some improved method or some new crop is not being demonstrated and none where some worn-out clay soils are not being rendered productive by the growth of velvet beans, cowpeas, soy beans, or other legumes.

REPORT OF THE AGRICULTURAL TECHNOLOGIST.

By W. A. Mack.

The personnel for demonstration work in the southern part of the island consists of the writer and two assistants. Much of the work has necessarily been carried on by correspondence, several hundred letters having been received and answered by the division and numerous others referred to members of the scientific staff of the station for action. The writer has visited farms in almost every section or municipality on the south coast of the island and has established cooperative relations with about 50 farmers. Campaigns for a greater production of foodstuffs have been launched. A liberal distribution of seed, plants, and agricultural literature has been made. Members of the station staff have on various occasions accompanied the writer for the purpose of giving advice and assistance along technical lines. Hundreds of farmers have visited the station to inspect the experimental and demonstration work carried on there, and great numbers have visited the cooperative demonstration plats in the various localities.

There were distributed among the farmers 2,000 packages of vegetable seed obtained from the United States Department of Agriculture, about 1,000 packages of seed from various field crops grown at the station, about 1,000 fruit and ornamental plants, and about 3,000 publications such as bulletins and circulars of the department and station.

Members of the division have assisted in the organization of an agricultural club, which is doing good work and bids fair to accomplish a great deal in disseminating valuable information among the farmers of the section where it is located and in furthering the work by improving social and business conditions among the small farmers. Members of the division have attended about 15 agricultural meetings, taking part in the discussions and using stereoptican views, charts, and photographs.

Members of the division have made it a point, when out on trips, to visit the school and town officials, and in many instances they have been given the opportunity of assisting or advising these officials in connection with the school gardens, tree planting, etc., in the towns. Also the school teacher or mayor of a town has often put the station in touch with farmers having some agricultural problem to solve or with progressive men able to cooperate in the demonstration work.

About two hundred farms have been visited, usually at the request of the planters, for consultation regarding some practice or problem on the farm, in some instances members of the station scientific staff having accompanied the demonstration workers. Some farms carrying on demonstrations have been visited several times so as to permit supervision of the work. A great number of farmers have visited the station, showing great interest in the demonstrations under way and in many cases putting some of the principles into practice.

In view of the unusual conditions now prevailing, great stress has been put on a greater production of foodstuffs. In this work recourse has been had to such measures as visiting the farms, consulting with the farmers, holding conferences in the various localities, writing newspaper articles, and sending out circulars encouraging the farmers to plant more food-producing crops. Flattering results have been obtained from this phase of the work. A great number of the cane planters have made a departure from their regular cropping system and have planted large areas to corn, beans, and root crops.

The organization of a chain of cooperative demonstration plats was begun with the object of demonstrating by concrete examples improved methods. Much attention has been given seed selection, cropping systems, soil conservation, etc., also demonstrations of the value of new crops and methods of handling these in different sections of the island. In much of this work the station serves in an advisory capacity, in many instances furnishing seed for planting to farmers, who do the work on demonstration plats according to instructions. As the operations on these plats are watched very closely by the neighbors of the cooperators, it is apparent that convincing results will have a good influence.

Owing to the wide variation of climatic and soil conditions in the different localities, it is often found that, while certain crops give good results in one section, some other crop will give better results a few miles away. The planting season and the cropping system also vary with the same crop in different localities. With these facts in mind, the division has made special efforts to encourage a system of more diversified farming by the introduction of new crops, and along this line it made the greatest achievements of the year. The crops used were rice, soy beans, Sudan grass, velvet beans, Napier grass, and new varieties of cowpeas, corn, and beans.

The farmers have been found very much interested in cooperating in this work, and in the case of rice many of them were eager to make extensive plantings. The extension of rice culture offers great opportunities, as climatic and other conditions seem favorable to the growing of this crop and as a ready market for the product is assured by the fact that rice is one of the principal articles of food in Porto Rico. One other point which adds to the attractiveness of rice culture is that there are great areas of land now lying idle which may be reclaimed and profitably planted to rice. All indications are that the rice industry is sure to make great strides as various irrigation projects are developed.

The soy bean also bids fair to become one of the principal crops, because of its food value and its hardiness, which makes it a much surer crop than most beans now planted in Porto Rico. Plantings of the soy bean have been made on the cooperative demonstration plats in various sections and have given good results. As soil inoculation has been carried out rather slowly, better results are expected when this is accomplished satisfactorily.

The several forage crops introduced are gaining a foothold with many farmers. It is hoped that the results from this work will be a greater production of very necessary stock food and the employment of a better cropping system than that generally followed in some localities.

○

THE UNIVERSITY OF MICHIGAN
GRADUATE LIBRARY

DATE DUE

UNIVERSITY OF MICHIGAN
3 9015 04878 5458

BOOK CARD
DO NOT REMOVE
A Charge will be made
if this card is mutilated
or not returned
with the book

GRADUATE LIBRARY
THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

PUERTO RICO-

GL

DO NOT REMOVE
OR
MUTILATE CARD